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VOLUME 34 APRIL 1956 NUMBER 2

RHABDOCHONA CHABAUDI N. SP. FROM BARBUS MERIDIONALIS[1]

BY PATRICIA MAWSON[2, 3]

Abstract

Rhabdochona chabaudi n. sp. is described from *Barbus meridionalis* from near Banyuls-sur-Mer, France.

The author has had the privilege of examining three vials of *Rhabdochona* species forwarded to Dr. Laurent P. E. Choquette by Dr. A. G. Chabaud of the Institut de Parasitologie, Faculté de Médecine of Paris. The worms are from *Barbus meridionalis* from near Banyuls-sur-Mer in France.

The material comprises three adult worms (8.0 to 8.2 mm. long), one young male (4.6 mm. long), and one ovigerous female (8.5 mm. long).

In both sexes the body tapers markedly towards the head end, less so towards the tail which ends in a short mucron; in the older male specimens the posterior end of the body is coiled spirally. Relatively large pocket-shaped amphids were seen in one specimen. The anterior end is funnel-shaped and bears six to eight toothlike projections; these are hard to see except in profile or in a semi *en face* view (Fig. 2). The cervical papillae are bifid and lie just posterior to the mid-length of the vestibule. The muscular oesophagus is slightly longer than twice the length of the vestibule (Fig. 1). In the male, the nerve ring surrounds the oesophagus at about the beginning of the second third of its length, and the excretory pore is a little behind this level, at about the mid-length of the muscular oesophagus. In the female specimen, the nerve ring and the excretory pore are farther forward. The glandular oesophagus is wide, occupying the whole of the body cavity. It extends from 1 : 2.4 to 1 : 2.7 of the whole body length in the adult male, 1 : 2.1 in the young male, and 1 : 2.8 in the female. The ratios of muscular to glandular parts in these three cases are 1 : 11–12, 1 : 10, and 1 : 13 respectively.

The male tail bears seven to eight pairs of preanal papillae, the most anterior of which is at the level of the proximal end of the resting spicule

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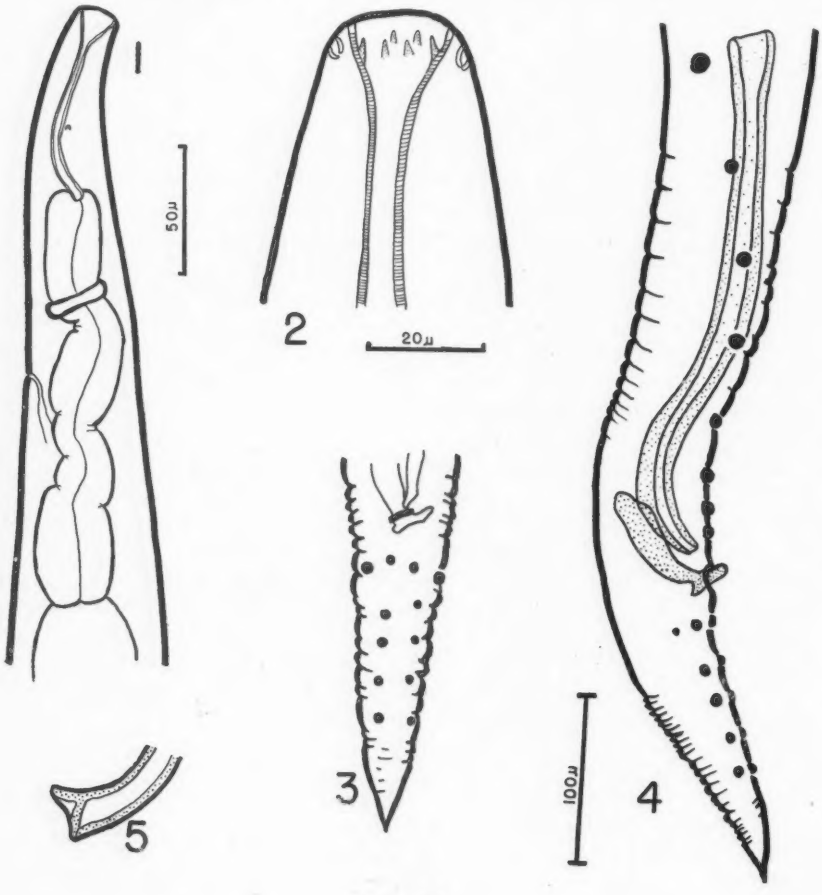
(Fig. 4). There are six pairs of postanal papillae, five of which are arranged equidistantly on the proximal two-thirds of the tail, and the sixth lateral from the first preanal one; this last is not always clearly seen in older males (Fig. 3). The tail of the young male is 0.17 mm. long. The longer spicule is 0.45 to 0.49 mm. in the older males, 0.34 mm. in the young specimen. The proximal half of this spicule is cylindrical; the distal half opens out as two widely separated rami joined by a thin wing; a short strut passes from one across to the tip of the other (Fig. 5). The shorter spicule is 0.11 to 0.12 mm. in the larger males, 0.10 mm. in the smaller; this is 1 : 3.9 to 1 : 4.4, respectively, of the length of the longer spicules. The shorter spicule has two wide, lightly cuticularized expansions at the proximal end; the shaft and tip are strong and the tip has a backward spur.



Figs. 1–5.

The vulva is a small transverse slit which lies at one-seventh of the body length from the anterior end. The eggs are crenelated and compressed into angular shapes. One oval egg near the vulva is 32 by 18 μ. The female tail measures 0.11 mm., but the cuticule is much wrinkled.

The species is close to *R. denudata* (Duj.) as described by Gnedina (1). In her material the cervical papillae are more anterior, the nerve ring is more anterior and is situated at a greater distance in front of the excretory pore, the ratio of lengths of the muscular to glandular parts of the oesophagus is 1 : 7 (1 : 9.3 to 1 : 13 above), and the egg size is greater. There is one more pair of postanal papillae in the present material than in *R. denudata*. The spicules are longer but of comparable ratio to body length. The ratio between the length of the oesophageal region and the whole body, and the position of the vulva (all calculated from the table of measurements given by Gnedina), are similar in both cases. The shape of the spicule tip is described by Gnedina as trifurcate but figured as bifurcate, with the branches lying parallel; this folded condition was not seen in any of the specimens described above.

Layman (2) records *R. denudata*, stating that his specimens were generally in accord with Gnedina's description. The measurements given by Layman for his worms were larger than those of Gnedina and of those described above (9.24 to 10.14 mm., 11.96 to 13.2 mm.). The ratio between the lengths of the large and small spicules (1 : 3.6) is greater than in Gnedina's material and within the range described above. The egg size is about the same as in the French material, smaller than in that of Gnedina. Other measurements were, unfortunately, not given by Layman.

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AMINO ACID REQUIREMENTS OF ORYZAEPHILUS SURINAMENSIS (L.) (COLEOPTERA: SILVANIDAE) FOR PUPATION[1]

By G. R. F. Davis[2]

Abstract

A racemic mixture of alanine in the diet was deleterious to *Oryzaephilus surinamensis* (L.) in the concentration used. Cystine, arginine, and proline were also harmful and the adverse effect of alanine may have been partially reduced by their removal from the diet. Data obtained with a chemically defined diet lacking alanine indicate that removal of proline or lysine had no effect. Removal of arginine, tryptophan, cystine, glycine, isoleucine, histidine, or methionine, one at a time, resulted in a lower percentage survival or a longer larval period, or both.

Introduction

Extensive reviews on insect nutrition have been compiled by Uvarov (12), Craig and Hoskins (1), and Trager (11). As early as 1935, the necessity of asepsis in insect vitamin research was recognized (13). In 1946, the first insect, *Drosophila melanogaster* Mg., was reared on a chemically defined diet (10). Hinton, Noyes, and Ellis (6) determined some amino acid and vitamin B requirements of *D. melanogaster*. House (7, 8), using a chemically defined diet under aseptic conditions, found five amino acids essential in the diet of *Blattella germanica* (L.). The importance of 10 amino acids in the nutrition of *Tribolium confusum* Duv. was investigated by Lemonde and Bernard (9). Casein had been used successfully as a source of protein in synthetic diets for several stored product insects (2). The present investigation was undertaken to determine the effect of omitting amino acids, singly and in pairs, from the protein portion of the diet of *Oryzaephilus surinamensis* (L.) larvae.

Materials and Methods

About 100 adults from a population that had been reared for several generations in flour enriched with 3% wheat germ were obtained to make an egg farm. Eggs were removed every 24 hr., sifted free of all flour and frass, and put in covered Petri dishes in a rearing cabinet at 32 ± 0.25°C. and 75 ± 5% relative humidity. Hatching occurred 72 to 96 hr. after the eggs were laid, with a mean time of about 84 hr., the age of larvae being calculated from 12 hr. before removal of the eggs from the egg farm.

The chemically defined diet (Table I) was adapted from a synthetic diet on which Fraenkel and Blewett (2, 3, 4) reared a species each of *Ptinus*, *Tribolium*, *Oryzaephilus*, *Stegobium*, and *Lasioderma*; three species of *Ephestia*; and *Plodia interpunctella* (Hbn.). A mixture of 18 amino acids was substituted for casein; dextrin for glucose; a mixture of pure vitamin B components,

[1]*Manuscript received October 3, 1955.*
This paper is based on a thesis prepared in partial fulfillment of the degree of Ph.D. in the Department of Zoology, McGill University, Montreal, Quebec.
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TABLE I

COMPOSITION OF THE CHEMICALLY DEFINED DIET

Amino acids	Gm.	Other components	Gm.
dl-Alanine	0.146	Dextrin	8.000
l-Arginine monohydrochloride	0.057	Inositol	0.005
l-Aspartic acid	0.081	Choline chloride	0.005
l-Cystine	0.004	Thiamine hydrochloride	0.0005
l-Glutamic acid	0.309	Riboflavin	0.0005
Glycine	0.066	Nicotinic acid	0.0005
l-Histidine monohydrochloride	0.040	Pyridoxine hydrochloride	0.0005
dl-Isoleucine	0.169	Calcium pantothenate	0.0005
l-Leucine	0.128	*p*-Aminobenzoic acid	0.0005
l-Lysine monohydrochloride	0.101	Cholesterol	0.042
dl-Methionine	0.090	Ergosterol	0.042
dl-Phenylalanine	0.133	Nucleic acid	0.050
l-Proline	0.103	Biotin	0.025γ
dl-Serine	0.204	Folic acid	0.00008
dl-Threonine	0.101	McCollum–Davis's salt	0.168
l-Tryptophan	0.008	Cellulose (powdered)	0.100
l-Tyrosine	0.089	Linoleic acid	0.060
dl-Valine	0.172	α-Tocopherol	0.0031
Total	2.001		

nucleic acid, biotin, ergosterol, and cholesterol for yeast; and McCollum–Davis's salt mixture No. 185 (General Biochemicals, Inc., Chagrin Falls, Ohio) for McCollum's salt mixture. Pablum mixed cereal (Mead, Johnson and Company of Canada, Limited, Belleville, Ontario) was used as a diet for the control larvae.

The dietary components were mixed in a mortar, placed in a ball mill for 12 to 18 hr. to ensure thorough mixing, and sprinkled in a thick layer on moist filter paper clamped in embroidery hoops. Circles just large enough to fit the bottoms of rearing jars 1½ in. in diameter and 3 in. high were cut from the dried preparation and placed in separate small containers for storage under refrigeration. The Pablum mixed cereal for the control larvae was prepared in the same way.

Twenty larvae were put on the food in each jar, the mouth of which was covered with a piece of unbleached cotton held in place by a rubber band. These jars were placed in a rearing cabinet at 32°C. and 75% relative humidity. The larvae were counted daily and the tests were conducted to the time of pupation only.

The requirement for an amino acid was tested by removing the acid from the diet. In order to maintain the nitrogen level, glycine was substituted for the amino acid removed.

The data were submitted to an analysis of variance after applying the arcsine transformation. To compare survival on various diets the method of least significant differences was applied at the 5% level.

Results and Discussion

The effects of omitting alanine and each of nine other amino acids together with alanine are recorded in Table II. The complete diet did not give sufficient survival to serve as a standard of reference. However, omission of alanine improved the diet enough that the effect of removing other amino

acids could be measured. Omission of proline or lysine produced no appreciable change in survival, but lack of proline shortened the developmental period considerably. Removal of arginine, tryptophan, cystine, glycine, isoleucine, histidine, or methionine, one at a time, resulted in a lower percentage survival or a longer larval period, or both.

Five of the tests were terminated before pupation was complete because they had covered a period equal to three times that obtained with the control diet. Of these, only the diet lacking cystine and alanine appeared capable of producing satisfactory survival.

The presence of alanine in the diet decreased the survival at least one-half (Tables II and III). Thus the racemic mixture of alanine, in the concen-

TABLE II

SURVIVALS AND TIMES TO PUPATION.
ALANINE AND EACH OF VARIOUS AMINO ACIDS BEING OMITTED FROM THE DIET

Amino acid(s) omitted*	No. larvae	% survival	Av. time to pupation (hr.)
Pablum mixed cereal, control	100	86.0‡	454.6 ± 53.6†
None	140	9.3‡	722.0 ± 204.2
Alanine	140	65.0	912.7 ± 173.3
Proline, alanine	100	72.0	680.0 ± 35.7
Lysine, alanine	100	66.0	928.6 ± 185.6
Arginine, alanine	100	44.0‡	1037.8 ± 307.0
Tryptophan, alanine	100	42.0‡	996.5 ± 243.4
Cystine, alanine	100	61.0?	Stopped at 1284.0
Glycine, alanine	100	55.0?	Stopped at 1308.0
Isoleucine, alanine	100	35.0?	Stopped at 1236.0
Histidine, alanine	100	34.0?	Stopped at 1332.0
Methionine, alanine	100	32.0?	Stopped at 1236.0

* *Glycine and alanine replaced by proline, others by glycine.*
† *Standard deviation.*
‡ *Significant at the 5% level in comparison with the diet lacking alanine only.*

TABLE III

SURVIVALS AND TIMES TO PUPATION.
ALANINE BEING PRESENT IN THE DIET AND EACH OF VARIOUS AMINO ACIDS BEING OMITTED

Amino acid omitted*	No. larvae	% survival	Av. time to pupation (hr.)
Pablum mixed cereal, control	100	86.0	454.6 ± 53.6†
Cystine.	80	35.0	678.0 ± 87.5
Arginine	80	27.5	867.0 ± 72.1
Proline	140	22.1	719.9 ± 158.5
Histidine	80	15.0	886.0 ± 147.6
Methionine	140	13.6	775.2 ± 228.6
Isoleucine	140	12.9	792.7 ± 131.9
Lysine	80	12.5	669.6 ± 165.3
None	140	9.3	722.0 ± 204.2
Valine	140	7.9	1116.0 ± 202.2
Glycine	80	7.5	724.0 ± 188.3

* *Glycine replaced by arginine, others by glycine.*
† *Standard deviation.*

tration used, was deleterious to the larvae. Table III indicates that cystine, arginine, and proline also were harmful or that the adverse effect of alanine was partially alleviated by their removal.

Lysine is a necessary dietary component for most animals; however, the results of this investigation indicate that *O. surinamensis* can do without it. Usually cystine and glycine are not essential factors of the diet, but *B. germanica* requires cystine (8), *D. melanogaster* requires glycine (6), and *Aëdes aegypti* L. requires both (5). The above results show that *O. surinamensis*, unlike most other animals, also needs cystine and glycine for growth.

These results do not permit a statement of absolute requirements for amino acids. They do illustrate the importance of the proper balance for amino acids in the diet. Until a chemically defined diet is devised in which a single amino acid may be made the sole limiting factor, no statement on the absolute requirements for amino acids can be made with certainty.

Acknowledgments

The writer wishes to thank Dr. John Stanley, Chairman of the Department of Zoology, McGill University, for assistance throughout the investigation and for suggesting the coated filter paper technique. Also, he desires to express his appreciation to the Charles E. Frosst Company, Montreal, for the donation of various B-vitamins, and to Ayerst, McKenna and Harrison Limited, Montreal, for supplying the folic acid used in these investigations. He is further indebted to Dr. H. M. Slatis, Department of Genetics, McGill University, and to Mr. C. Reimer, Statistical Research and Service Unit, Canada Department of Agriculture, for aid in outlining the statistical methods for comparing the diets.

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THE PHYSIOLOGY OF DORMANCY IN THE SWEETCLOVER WEEVIL[1]

By K. G. Davey

Abstract

The physiology of the overwintering adult stage of *Sitona cylindricollis* (Fahr.), the sweetclover weevil, has been examined. It has been shown that the dormancy is characterized by a drop in oxygen consumption, a cessation of development in the reproductive organs, and a slight rise in fat content; and that the termination of dormancy is characterized by a reversal of these conditions. The water content does not change. Although the total respiration exhibited the characteristic U-shaped curve from entry into dormancy until its cessation, the CO-insensitive respiration remained at a low level throughout. Termination of the dormancy requires a period of exposure to low temperatures. It is concluded that this dormancy is not essentially different from diapause in immature insects.

Introduction

Dormancies in immature stages of various insects have been intensively studied for some time. Eggs of *Melanoplus differentialis* exhibited a spontaneous cessation in development (i.e. diapause) characterized by a cessation of mitosis (18) and a low level of respiration (1, 5, 11). The decrease in respiration during diapause and its subsequent increase after the termination of diapause was a result of a decrease and increase in the cyanide-sensitive respiration (2). The same observations were made with respect to the CO-inhibited respiration (3). Diapause in *Platysamia cecropia* pupae, where respiration undergoes a similar reduction, has been shown to be characterized by an almost complete disintegration of the cytochrome system. Resumption of development is accompanied by a reconstitution of this system (15, 16). Larval diapauses also occur and have been studied in detail in *Lucilia sericata* (6). Evidently the cytochrome activity, although it does show a certain decrease, does not disappear to any great extent as shown by the results obtained with larvae of *Popillia* (8) and *Pristiphora* (9). The diapause in the adult of *Leptinotarsa decemlineata* has been the subject of physiological studies (7, 22). This dormancy is characterized by a decreased metabolism, a low water content, and a high fat deposit which decreases gradually as the dormancy proceeds.

A second type of dormancy, totally dependent upon environmental conditions, has been observed in many insects, especially in the adult stage. Such a condition, where entry into and exit from dormancy is determined by the environment, has been called quiescence (17). The term hibernation has also been applied, but this word is frequently used synonymously with diapause.

[1]*Manuscript received October 7, 1955.*
Contribution from the Department of Zoology, University of Western Ontario, London, Ontario. This investigation was financially aided by a scholarship from the Research Council of Ontario.

In view of the more recent developments in diapause physiology, the study of adult dormancy in another species would appear to be of interest. The present work concerns the physiology of the dormancy in the sweetclover weevil, *Sitona cylindricollis* (Fahr.). It includes an investigation of the respiratory rate, a consideration of the cytochrome system and observations on activity, water content, fat content, and condition of the gonads. The effect on the dormancy of food and length of exposure to low temperature is also considered.

Methods and Materials

Insect Material

The insects used in this study were collected during July and August, 1954, by sweeping after dark in a ditch where they congregated in fairly large numbers. After having been assessed for oxygen uptake, the weevils were placed in groups of 200 into Sealrite containers with a little moist vermiculite and kept under refrigeration at about 5° C. About ten thousand weevils were collected in this manner. Most of the weevils were not fed, but after the first three weeks of captivity water was added to each box every week.

Oxygen Uptake

The oxygen uptake in air of whole weevils was determined manometrically in the Warburg apparatus. Ten adults were placed in a gelatin capsule punctured several times with a hot needle. Each capsule was placed in the moat of a Warburg vessel. The center well contained 0.3 ml. of 20% KOH with filter paper to serve as a wick. The water bath was maintained at 27° C. After temperature equilibration for 15 min., readings were taken at 10-min. intervals for one hour. Respiratory rates were expressed as cu. mm. of O_2 consumed by 1 mgm. dry wt. of insect per hr. or cu. mm./mgm./hr.

Activity

Qualitative observations were made on locomotory, reproductive, and other activity.

Water Content

Water content of weevils was measured by drying weighed samples of 50 weevils to constant weight at 105° C. Twelve determinations were made at intervals between August 17, 1954, and January 5, 1955.

Fat Content

The fat content was determined as the percentage of ether-extractable material on the basis of the dry weight of the insect. Dried, weighed weevils from the water content determinations were extracted with diethyl ether in a micro-Soxhlet apparatus for six hours. The extract was evaporated to dryness and the residue was dried over calcium chloride to a constant weight.

Development of the Gonads

An indication of the progress of development in the adult was obtained by making observations on the condition of the gonads. This information was obtained by examining paraffin sections of the abdomen cut at 10 microns and stained with Ehrlich's haematoxylin and eosin.

CO-insensitive Respiration

This was determined with the apparatus and method of Schneiderman and Feder (13). Four atmospheres of CO were superimposed on 1 of air in order to give the 19 to 1 CO/O_2 ratio necessary to achieve a 75% inhibition of the cytochrome system (19). Four determinations using nitrogen instead were made in order to determine the effect of pressure alone. In both cases, the gases were obtained from Matheson and Co., Joliet, Ill.

A few determinations of the effect of CO were made at atmospheric pressure by using the Warburg flasks and flushing them with a 9 to 1 mixture of CO and air. Since there was definite danger of anoxia, this method was discarded early in the study.

Effect of Low Temperature

The effect of exposure to low temperature on the dormancy was examined by removing boxes of weevils from refrigeration at intervals of about two weeks beginning October 20, and examining them at 27° C. Each box of weevils, therefore, had been exposed to 5° C. for a different length of time, the periods ranging from 74 to 155 days. The weevils were then assessed for O_2 uptake at regular intervals.

Effect of Food on Dormancy

In order to test the effect of food on the entry into dormancy, four groups of weevils, each group comprising 400 weevils distributed between two containers, were treated as follows:

Group A — temperature 5° C.; weekly food.
Group B — temperature 5° C.; no food.
Group C — temperature 27° C.; no food.
Group D — temperature 27° C.; weekly food.

The food consisted of young sweet clover foliage. Oxygen determinations were made every two weeks. This experiment began on September 28 and continued until November 30 when all the weevils kept at 27° C. were dead.

The effect of food on emergence from dormancy was tested by feeding some of the weevils which were emerging from dormancy and noting the respiratory rate at frequent intervals.

Results

Oxygen Uptake

Results obtained from regular determinations of the oxygen consumption of *Sitona cylindricollis* are shown in Fig. 1. The line is drawn through the mean oxygen uptake for the corresponding date. The dots represent the separate

oxygen uptake determinations from which the mean was computed. The 95% fiducial limits for each series of determinations are represented by short horizontal lines. The group of points from July 20 to September 22 represent the initial readings obtained in weevils as they were taken from the field, while the group from September 28 to January 3 were the readings obtained on these weevils which had been stored at 5° C. until December 17, when they were placed at 27° C.

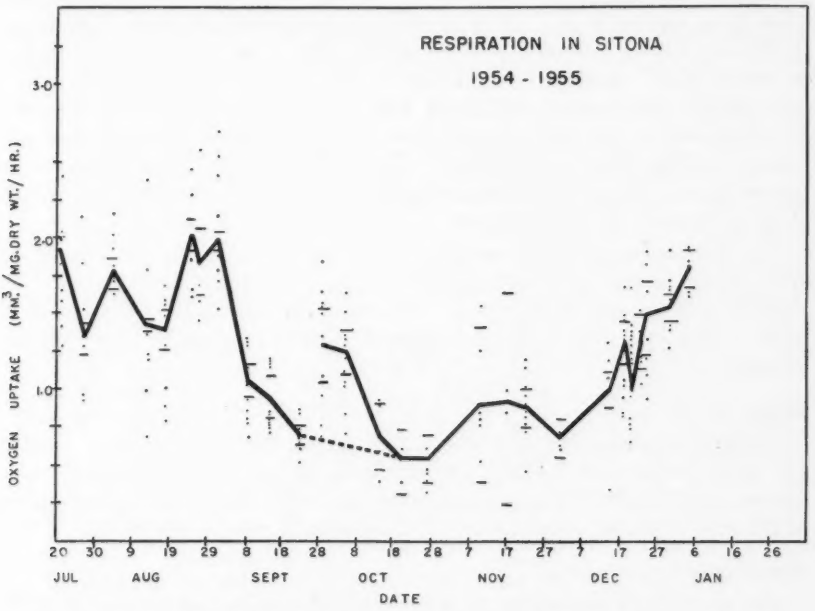

FIG. 1. Respiration in adult *Sitona*, July 1954 – January 1955. The curve is drawn through the means of the separate determinations which are represented by dots. The short horizontal lines indicate the 95% fiducial limits.

It will be noted that the readings obtained from weevils taken directly from the field varied about a mean oxygen uptake of 1.71 cu. mm./mgm./hr., and that in the first week in September it dropped rapidly to 0.70. The readings from the refrigerated weevils, obtained one month later, dropped from 1.26 to a low level of 0.54, or slightly less than $\frac{1}{3}$ of the predormant level. It is likely that respiration in the field would have continued to drop and therefore the two groups of readings have been joined on the graph by a broken line. It will be seen that the course of the respiration during dormancy in *Sitona* followed the U-shaped curve characteristic of other dormancies. Although the insects were not removed from refrigeration until December 17, some rise in oxygen consumption occurred before that date. The uptake continued to rise until January 3 when the observations were terminated.

Activity

At the time of their discovery towards the end of July, the weevils were congregated along 100 yards of a roadside ditch, and were completely absent in the rest of the ditch and adjoining fields of seedling sweet clover. At the beginning of September, this aggregation had begun to descend to the ground trash and progressively fewer weevils were caught by sweeping. No mating or flying activity was observed during the predormant or dormant periods.

The dormant weevils did not cease feeding, but ate fresh sweet clover leaves when these were offered. Food, however, is not essential during dormancy, as the majority of the weevils were not fed. The insects retained the power of locomotion, running about when disturbed, occasionally exhibiting spontaneous movements. The locomotion was, however, decidedly sluggish. A pronounced thigmotaxis was observed in both dormant and non-dormant weevils, but this behavior appeared to be more pronounced among the former. In general, the activity of dormant insects did not differ in quality from that of active weevils but was markedly reduced in intensity.

After emergence from the low respiration phase (i.e. at the termination of dormancy), the insects became considerably more active and fed voraciously. Thigmotaxis was still in evidence. Postdormant insects have been seen in flight in the field. Mating was observed within two weeks after the rise in respiration.

Water Content

Twelve determinations of water content made during the period August 17, 1954, to January 5, 1955, showed little variation. The mean water content was 45.1% with a standard error of $\pm$ 1.4. There was no indication of the drop in water content noted as *Leptinotarsa* entered dormancy (7, 22).

Fat Content

The fat content of samples of 50 weevils, the same as had been used in the water determinations, is shown in Table I. It is seen that its level rose from less than 15% in July to approximately 20% in August. This period of rising fat content slightly preceded the dormancy. The level stayed steady throughout the dormant period. After the termination of dormancy in December and the resumption of a high oxygen uptake, the fat content fell to a level below 15% in January. It may also be noted that the drop in fat content was greater in starved individuals, but it is impossible to ascribe significance to this difference.

Development of the Gonads

That a true dormancy does exist in *Sitona* is indicated by the condition of the gonads during the low respiration period as seen in histological sections.

The ovaries, located in the dorsal abdomen, are compact ellipsoid bodies during the dormant period. The cells are small and tightly packed, with a cross-sectional area of 0.48 sq. microns. There are no division figures. These observations are based on weevils killed November 15 and 23.

The ovaries of weevils which had emerged from dormancy presented a considerably different picture. The oöcytes were much larger, with a cross-sectional area of 0.79 sq. microns, probably as a result of yolk deposition. In one case, a mature oöcyte was observed just 10 days after return to 27° C. No increase in cell numbers was apparent; division figures were absent.

The changes in the male are less distinct. In the dormant testis, there are no division figures. The almost completely differentiated spermatozoa remain encysted. No free sperms are apparent within the testis and the various associated ducts contain no sperms. Intermediate stages between spermatids and spermatozoa are rare.

TABLE I

FAT CONTENT OF *Sitona* ADULTS DETERMINED AS THE PER CENT ETHER-EXTRACTABLE MATERIAL ON THE BASIS OF DRY WEIGHT

Date		Fat content, %
July	19	14.8
July	23	13.0
August	3	18.0
August	8	19.7
August	15	22.2
August	23	19.2
August	30	18.2
September	8	19.8
September	14	24.0
October	13	17.4
October	26	17.1
November	11	20.0
November	13	28.2
December	14	20.0
January	5	12.5 (unfed)
January	5	14.7 (fed)

The most obvious change in the postdormant testis is the freeing of mature sperms from the cysts. The ducts now contain spermatozoa. A few division figures are to be seen among the spermatocytes at the periphery of the testis. A number of the cysts contain stages in spermiogenesis.

CO-insensitive Respiration

Measurements were taken of the CO-insensitive respiration from the time the weevils entered dormancy until they had completely recovered from it. For each determination at least three groups of 20 to 40 insects were exposed to high pressures consisting of 4 atmospheres of CO superimposed on 1 atmosphere of air. The readings taken prior to October 20 were from field

weevils; the remainder were from refrigerator stock. The determinations on January 3 involved weevils returned to 27° C. on December 17. The data appear in Table II.

TABLE II

CO-INSENSITIVE RESPIRATION: OXYGEN UPTAKE OF *Sitona* ADULTS UNDER THE INFLUENCE OF 4 ATMOSPHERES OF CARBON MONOXIDE SUPERIMPOSED ON 1 ATMOSPHERE OF AIR

Date		Oxygen uptake (cu.mm./mgm.hr.)
August	23	1.00
August	30	1.40
September	8	0.72
October	20	2.30
October	26	0.50
November	9	0.97
December	8	0.98
December	13	1.90
December	17	3.00
January	3	1.60

It was noted that these rates of oxygen consumption were no less than the rates determined for the intact respiration (see Fig. 1). It was therefore suspected that the pressure of 5 atmospheres was stimulatory in effect. This was tested by substituting nitrogen for carbon monoxide as the experimental gas. The oxygen uptake under this pressure as compared with that obtained for the same insects under normal pressure in the Warburg apparatus is tabulated in Table III.

TABLE III

EFFECT OF PRESSURE PER SE: COMPARISON OF RESPIRATION UNDER 5 ATMOSPHERES (NITROGEN : AIR, 4 : 1) WITH THAT IN AIR AT 1 ATMOSPHERE

Date		Uptake in air	Uptake under pressure
January	23	0.67	5.60
January	24	0.51	2.00
March	19	1.21	4.63
March	20	1.02	4.00

It is apparent that the normal respiration was increased about four times by the effects of compression. Therefore, the data on normal respiration obtained in the Warburg apparatus must be multiplied by four if they are to be compared with the CO-insensitive fraction obtained under pressure. This has been done in the graph in Fig. 2.

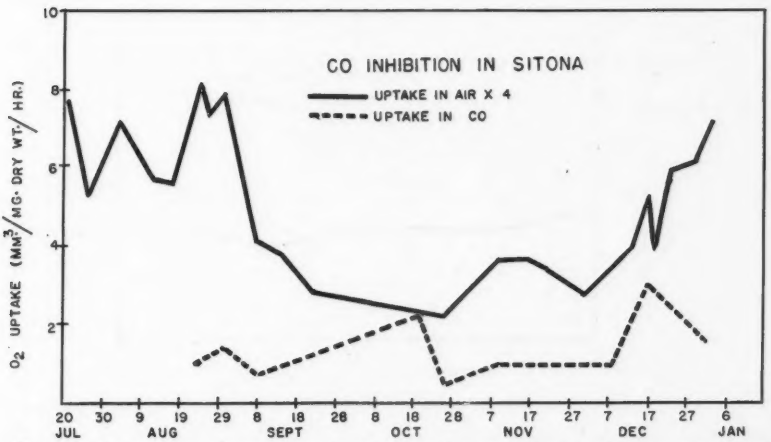

FIG. 2. Comparison of respiration in *Sitona* under the influence of 4 atmospheres of CO superimposed on 1 of air (broken line) with that in air multiplied by 4 (solid line).

From this graph it is apparent that the CO-inhibited respiration remains at a low level during the predormant and dormant periods and that this CO-insensitive fraction constitutes about one-third of the total respiration during dormancy. A slight rise in the CO-insensitive fraction accompanies the considerable rise in total respiration at the termination of dormancy.

Further justification for the manipulations outlined above is obtained from experiments with CO at atmospheric pressure. In these experiments the Warburg vessels containing the weevils were flushed with a 4 : 1 mixture of CO : air or N_2 : air. On August 24, eight groups of 10 insects had an average uptake in air of 2.15 cu. mm./mgm./hr. and an uptake in CO and air of 0.97. This represents a 55% inhibition. Again on September 1, nine groups of 10 had an average normal uptake of 1.89 cu. mm. and an inhibited uptake of 0.99, representing a 48% inhibition. The uptake in the nitrogen–air mixture as measured on August 26 on four samples of 10 insects showed only a 30% inhibition (1.84 in air; 1.28 in nitrogen and air).

Effect of Low Temperature

A total of 11 boxes of weevils were returned to 27° C. after various periods at 5° C. Those maintained at 5° C. for 74, 86, and 91 days showed no appreciable rise beyond the dormant level after four to six weeks at 27° C. The respiration of a typical group is indicated in Fig. 3.

The remaining eight boxes were stored at 5° C. for periods ranging from 101 days to 155 days. All of these showed an almost immediate rise in respiration and reached the predormant level of 1.7 cu. mm./mgm./hr. after two to three weeks at 27° C. A typical respiration curve is shown in Fig. 4.

In five of the eight groups, the initial respiration on removal from refrigeration was greater than the dormant level and lay between 1.0 and 1.5 cu. mm./mgm./hr.

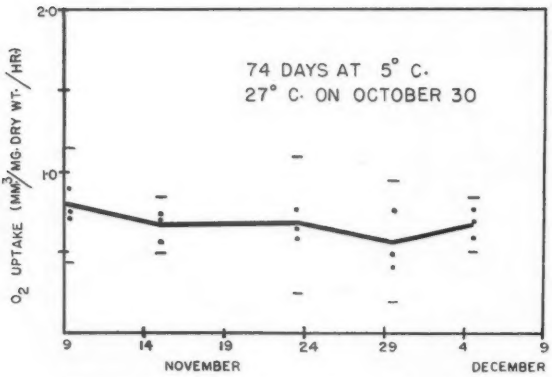

FIG. 3. Respiration of weevils returned to 27° C. on October 30 after exposure to 5° C. for 74 days.

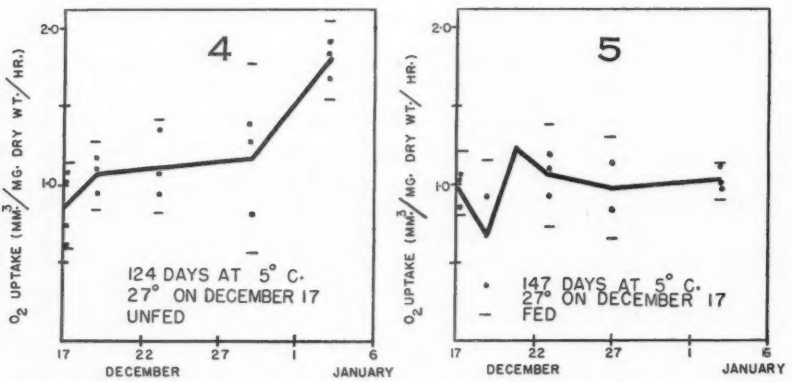

FIG. 4. Respiration of weevils returned to 27° C. on December 17 after exposure to 5° C. for 124 days.

FIG. 5. Respiration of fed weevils exposed to 5° C. for 147 days. Note that the respiration failed to rise to the level of postdormant adults.

Effect of Food on the Dormancy

Table IV shows the effect of feeding weevils, which were about to enter dormancy, at both 27° C. and 5° C. Even at the lower temperature these weevils were observed to feed and make leaf notches. While it is clear that the course of entry into dormancy (i.e. dropping respiration) is not altered by feeding, a possible retarding effect of food is indicated among fed weevils maintained at 27° C.

It was possible to modify the respiration of weevils emerging from dormancy by feeding. Under these circumstances, the respiration fell immediately, and then rose, but did not reach the level associated with non-dormant weevils. Such a situation is represented in Fig. 5.

TABLE IV

EFFECT OF FEEDING: AVERAGE OXYGEN UPTAKE OF FED AND STARVED *Sitona* EXPOSED TO 5° C. AND 27° C.

Date	27° C.		5° C.	
	Fed	Unfed	Fed	Unfed
September 28	1.39	1.30	1.19	1.12
October 4	1.34	1.08	1.32	1.34
October 11	1.40	1.05	1.26	1.19
October 19	1.35	0.62	0.99	0.54
October 25	0.96	0.69	0.64	0.45

Discussion

This work shows that the typical U-shaped curve characteristic of diapause in other insects (1, 14) occurs in the dormancy in *Sitona*. The respiratory rate began to fall in early September, while temperatures were fully de- elopmental. It is of further interest that in weevils which were refrigerated, the drop was delayed by one month, presumably as a result of the low temperature delaying the maturation process. It is possible that a certain stage in development must be reached before the dormancy begins.

Bodine and his co-workers have ascribed the drop in oxygen consumption during diapause to a loss in activity of the cytochrome system (2, 3). These observations have been extended by Schneiderman and Williams (16). While it is true that both tyrosinase and cytochrome oxidase are inhibited by carbon monoxide (19), it is clear that tyrosinase plays very little part in the metabolism of development and that cytochrome oxidase is the terminal oxidase associated with growth (21). In experiments performed on *Platysamia* pupae, Schneiderman and Williams (16) found that inhibition of respiration by CO was entirely a result of cytochrome oxidase inhibition. For these reasons the inhibition in *Sitona* is considered to be a result of inhibition of the cytochrome oxidase system.

It should be pointed out that, in these experiments with *Sitona*, the employment of the Schneiderman–Feder method, which ensured a ratio of 19 : 1 $CO : O_2$ in the volumeters and consequently a 75% inhibition of cytochrome oxidase (19), did not apparently depress the respiratory rate of the weevils. Supplementary tests showed that the effect of high pressure per se was to increase the respiratory rate four times. Therefore, an unchanged respiratory rate under CO and pressure represents a 75% inhibition masked by the fourfold stimulatory effect of pressure.

If the assumption that the cytochrome system is the principal enzyme system affected by CO is accepted, it is clear that entry into dormancy in *Sitona* is accompanied by a partial uncoupling of the cytochrome system resulting in a decreased oxygen consumption. Emergence from dormancy is marked by a reconstitution of the enzyme system and a consequent rise in

metabolism. Although entry into diapause in *Platysamia* is marked by a virtual disappearance of the cytochrome system, it appears that at least one-half of the dormant metabolism in *Sitona* is mediated via the cytochrome system.

The water content in *Sitona* does not change during the predormant, dormant, and postdormant periods. In this respect it resembles the larval diapause of *Cephus* (12), while differing from the egg diapause in *Melanoplus* (4), the prepupal diapause of *Gilpinia* (10), and the adult diapause of *Leptinotarsa* (7, 22).

Although the accumulation of fat in maturing larvae is well known, its accumulation in adults prior to entry into dormancy is not so well known. This observation, already reported by Fink for *Leptinotarsa* (7), has been repeated for these experiments on *Sitona*. On the other hand, although the fat content subsequently fell during the dormancy of *Leptinotarsa*, it stayed at a constant percentage of the body weight during dormancy of *Sitona*. Apparently, the metabolism during dormancy in *Sitona* was either insufficient to cause a detectable reduction in fat content or did not oxidize fat preferentially over other metabolites. With the termination of dormancy, however, the fat content falls, probably as a result of the demands made by the tripled metabolism.

The termination of dormancy in *Sitona* is signalled by an increase in size of the ovary cells. This increase is presumably a result of yolk deposition. Wigglesworth has demonstrated that the corpus allatum initiates yolk deposition in *Rhodnius* (20) and it is possible that the corpus allatum plays a role in the termination of dormancy in *Sitona*. Indeed, the corpus allatum has been shown to play a role in the termination of diapause in *Leptinotarsa* (23).

These experiments show that a period of exposure to low temperatures of more than 100 days is necessary to terminate the dormancy in *Sitona*. In the groups of weevils removed after 100 days at 5° C., six out of eight showed a slight delay before their oxygen uptake increased (see Fig. 4). This suggests that *Sitona*, like *Platysamia* (24) and *Cephus cinctus* (12), also requires a period of exposure to warmer temperatures to terminate the dormancy. It is equally noteworthy, however, that in the other two groups there was no lag in the rise of respiration. Salt found that the termination of diapause in *Cephus* requires not only an accumulation of subdevelopmental temperatures, but also an accumulation of temperatures in a warmer range and that the warm and cold ranges actually overlap (12). This would explain the fact that some weevils developed an increased respiratory rate before they were removed from refrigeration.

It is clear that in many respects the dormancy in adult sweetclover weevils is not very different from diapauses in immature stages of other insects. While it is true that this dormancy possesses certain peculiar features such as the retarding effect of food on the entry into and emergence from dormancy, it is strikingly similar to diapause with respect to respiratory metabolism,

development, cytochrome activity, fat and water content, and temperature relations. *Sitona*, then, undergoes a diapause which interrupts its development from a functionally immature insect to a functional adult capable of reproduction.

Acknowledgments

The author is indebted to Dr. A. W. A. Brown, Head of the Department of Zoology, University of Western Ontario, for suggesting the problem and for supplying advice and guidance during the work. Early phases of the work were done while the author was employed at the Entomology Laboratory of the Department of Agriculture, Chatham, Ontario, where Mr. G. F. Manson, director of the laboratory, made all the necessary facilities available. Mr. D. I. V. Lalonde of that laboratory offered his assistance during the work. The glassware for the high pressure respirometer was constructed by Mr. J. R. W. Miles of the Chatham laboratory.

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PLACOCONUS: A NEW GENUS FOR ARTHROCEPHALUS LOTORIS (SCHWARTZ, 1925) CHANDLER, 1942[1]

By Gloria A. Webster[2]

Abstract

After examining hookworms from raccoons, skunks, and dogs, the author believes that *Arthrocephalus lotoris* should be removed from the genus *Arthrocephalus* and made the type of a new genus, *Placoconus*. *Arthrocephalus maxillaris* may also belong to the new genus.

In 1925 Schwartz (6) described a hookworm from a raccoon (*Procyon lotor*) captured in Maryland, U.S.A. Prior to this time, Molin (4) reported two hookworms from the South American raccoon (*Procyon cancrivorus*), *Dochmoides bidens*, and *Dochmoides maxillaris*. Molin's inadequate descriptions of these made it impossible for Schwartz to relate his worms to either of them and consequently he described it as a new species, *Uncinaria lotoris*.

Uncinaria lotoris Schwartz, 1925 has a long buccal capsule whose surface is divided by a number of sutures into five sections. The dorsal wall of the capsule presents a series of narrow lacunae running on each side of the dorsal gutter, and there are two ventral teeth which are triangular in shape.

Chandler (3), in a study of helminth parasites from Texas raccoons, removed *U. lotoris* from the genus *Uncinaria* and combined it with the genus *Arthrocephalus*.

The genus *Arthrocephalus* was established by Ortlepp (5) for an "Ankylostome" collected from the intestine of an African mongoose. In his discussion Ortlepp states,

> "A new genus has been created for the reception of the above described species because it showed a combination of characters which together did not agree with any of the hitherto known genera of ancylostomes . . . the entire absence of buccal lancets is a character distinguishing it from all the known members of the Ancylostomidae. In addition, this genus is characterized by possessing a completely articulated buccal capsule, a well developed dorsal cone, no oral teeth, and the female genitalia are arranged longitudinally without lateral folds."

The sutures and arrangement of plates in *U. lotoris* are similar to those of *Arthrocephalus gambienses* Ortlepp, 1925, and because of this fact Chandler (3) states, ". . . . there can be no question that the two are congeneric." He states further,

> ". . . . it (*U. lotoris*) more nearly resembles members of the genus *Uncinaria* in which Schwartz placed it, but in the writer's opinion the articulated character of the buccal capsule, shared by these two species, is sufficient reason for retaining Ortlepp's genus."

[1]*Manuscript received January 30, 1956.*
Contribution from the Institute of Parasitology, McGill University, Macdonald College P.O., Que., Canada.
[2]*Junior Research Assistant.*

Owing to the fact that in some characteristics the worms do not agree, Chandler (3) proposed that the genus be emended and the following characters dropped: absence of ventral lancets, presence of a dorsal cone, and longitudinal arrangement of female genital organs.

Vaz (7) redescribed the hookworm from South American raccoons under the name *Arthrocephalus maxillaris* (Molin, 1860). This species may prove to be identical with *Arthrocephalus lotoris* (Schwartz, 1925) Chandler, 1942. The dorsal cone is absent, and Vaz states that no ventral lancets are present. In the written description articulating plates are described, but they are not shown in the figures, consequently it is difficult to determine exactly where this species belongs without further examination of the type material.

During a recent study of parasites of skunks, the striking resemblance of *A. lotoris* to *Dochmoides stenocephala* (Railliet, 1884) Cameron, 1924 was noted. This prompted a study of *A. lotoris* and *D. stenocephala* to determine their taxonomic relationship.

A. lotoris was represented by specimens from both the raccoon (*Procyon lotor*) and the skunk (*Mephitis mephitis*). Forty specimens of *D. stenocephala* from three hosts, the dog, the fox, and the wolf were examined.

The morphological affinities of *A. lotoris* to *D. stenocephala* (Fig. 3) outnumber their differences. These two species are more closely related morphologically than the three species now assigned to the genus *Arthrocephalus*. The elongate shape of the buccal capsule as well as the dentition and dorsal gutter are common characteristics. The cutting plates surrounding the cavity are similar; however, *A. lotoris* has lacunae in the dorsal wall and the buccal capsule is made up of articulating parts. The bursae are similar and the female reproductive organs are primarily looped in longitudinal folds in both genera.

In spite of these characters, which establish the very close morphological relationship of *A. lotoris* to *D. stenocephala*, the buccal articulations are, as Chandler states, sufficient reason for eliminating it from the genus *Dochmoides*.

The genus *Arthrocephalus* is comprised of three species each with the distinctive articulating type of buccal capsule; exclusive of this one attribute they have little in common.

Arthrocephalus gambienses.	Dorsal cone, no teeth (Fig. 2).
Arthrocephalus lotoris.	No dorsal cone, teeth (Fig. 1).
Arthrocephalus maxillaris.	No dorsal cone, no teeth.

The absence of a dorsal cone and the presence of ventral teeth are morphological characteristics which are useful in making generic determinations. Cameron (2) says,

> ". . . . it must be admitted that the presence of cutting plates and the absence of a dorsal cone are two very useful points for the identification of the genus."

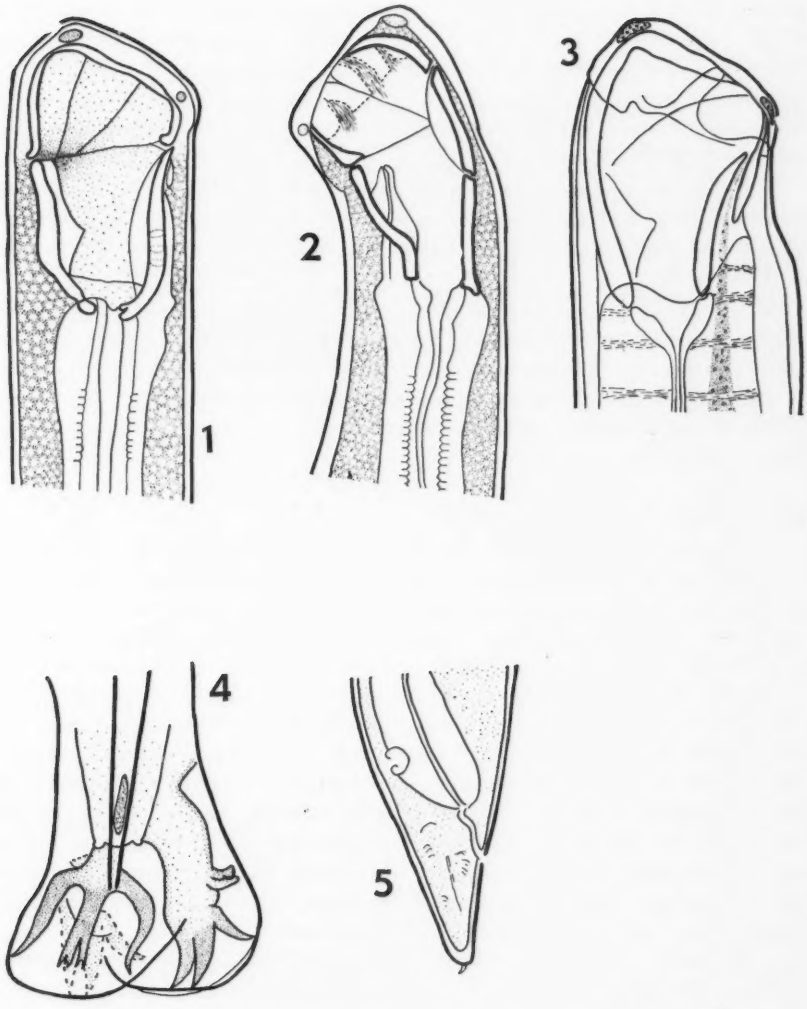

FIG. 1. *Placoconus* (= *Arthrocephalus*) *lotoris*.
FIG. 2. *Arthrocephalus gambienses* after Ortlepp.
FIG. 3. *Dochmoides stenocephala* after Cameron.
FIG. 4. *P. lotoris*, bursa of male.
FIG. 5. *P. lotoris*, tail of female.

Likewise, in each generic description of the Ancylostomidae given by Baylis and Daubney (1) the shape of the buccal capsule, presence or absence of a dorsal cone, and the type of dentition, as well as the bursal ray pattern are given as key characters to the genera. In the genus *Arthrocephalus* the dorsal cone and teeth characters are used for species differentiation; if they are to be retained in this capacity the taxonomy of the Ancylostomidae would necessarily need revision.

It is the author's opinion that *U. lotoris* does not belong to the genus *Arthrocephalus*, but that it is representative of a new genus, very closely related to, but distinct from, both *Dochmoides* (*Uncinaria*) (2, 8) and *Arthrocephalus*.

It is suggested, therefore, that the genus *Arthrocephalus* be retained as originally set forth by Ortlepp (5), with *A. gambienses* as the type species, and that a new genus, ***Placoconus*** be erected to contain *U. lotoris*, and pending further examination of the type material, possibly *A. maxillaris*. *Placoconus* occurs in the Western Hemisphere and is found primarily in Procyonidae but also occurs in the Mustelidae.

Generic Description

Medium size ancylostome. Head slightly bent dorsally. Mouth capsule longer than broad. The oral opening is guarded by cutting plates, the ventral wall exhibiting a separation of these plates, and the dorsal wall a series of narrow lacunae in the vicinity of the dorsal gutter. The surface of the mouth capsule presents grooves or deep furrows which divide it into five sections. There are two transverse sutures and two longitudinal sutures. The most anterior transverse suture extends from the area of the separation in the ventral wall across the widest portion of the capsule to the dorsal wall. From this, two small longitudinal sutures run to the anterior cutting plate. A remaining short transverse suture is located in the posterior portion of the capsule behind the base of the ventral teeth. A dorsal cone is absent; ventral teeth are present and triangular in shape. The bursa has two large lateral lobes and a small dorsal lobe. The lateral rays originate from a common stem, the anterolateral ray diverges from the other lateral rays. The base of the mediolateral ray may be slightly thicker than that of the posteriolateral. Spicules are equal, long, and tubular. Female genitalia are primarily arranged in longitudinal folds. Vulva located near the posterior third of the body.

Host: *Procyon lotor* and *Mephitis mephitis*.
Location: Small intestine.
Distribution: North America.
Type species: *Placoconus lotoris* (Schwartz, 1925).
Other species: ? *Placoconus maxillaris* (Molin, 1860) Vaz, 1935, from *Procyon cancrivorus*, South America.

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ON A COLLECTION OF AVIAN CESTODES FROM CANADA

By June Mahon[2]

Abstract

Twenty species of cestodes are recorded from Canadian birds.

Introduction

The cestodes studied in this paper form part of the collection of the Institute of Parasitology, and are listed in systematic order. The host names were checked according to Peters (19).

List of Cestodes

PSEUDOPHYLLIDEA Carus, 1863

DIPHYLLOBOTHRIIDAE Lühe, 1910

Ligulinae Lühe, 1899

Ligula intestinalis (Lin., 1758)

TETRABOTHRIDEA Baer, 1954

TETRABOTHRIIDAE Braun, 1900

Tetrabothrius cylindraceus (Rudolphi, 1819)
Tetrabothrius erostris (Lönnberg, 1899)
Tetrabothrius immerinus (Abildgaard, 1790)
Tetrabothrius sp.

CYCLOPHYLLIDEA Braun, 1900

DAVAINEIDAE Fuhrmann, 1907

Davaineinae Braun, 1900

Davainea proglottina (Davaine, 1860)
Raillietina (*Skrjabinia*) *cesticillus* (Molin, 1858)
Raillietina (*Skrjabinia*) *variabila* Leigh, 1941

DILEPIDIDAE Fuhrmann, 1907

Dilepidinae, 1907

Gryporhynchus tetrorchis Hill, 1941
Lateriporus geographicus Cooper, 1921

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Paruterininae Fuhrmann, 1907

Paruterina candelabraria (Goeze, 1782)
Rhabdometra odiosa (Leidy, 1887)

Hymenolepididae Fuhrmann, 1907
Hymenolepidinae Perrier, 1897

Diploposthe laevis (Bloch, 1782)
Drepanidotaenia lanceolata (Bloch, 1782)
Echinocotyle rosseteri Blanchard, 1891
Haploparaxis parafilum Gasowska, 1931
Hymenolepis furcifera (Krabbe, 1869)
Hymenolepis multiformis (Creplin, 1829)

Taeniidae Ludwig, 1886

Cladotaenia foxi McIntosh, 1940

Acoleidae (s.l.) Fuhrmann, 1907

Progynotaenia americana Webster, 1951

Amabiliidae Braun, 1900

Tatria biremis Kowalewski, 1904

Pseudophyllidea Carus, 1863

Ligula intestinalis (Lin., 1758)

Hosts: *Mergus merganser americanus* (Cassin) (Anseriformes), Ottawa River, Ste. Anne de Bellevue, Que.
"Arctic diver" (Gaviiformes), Ungava.
This parasite is common in a variety of fish-eating birds.

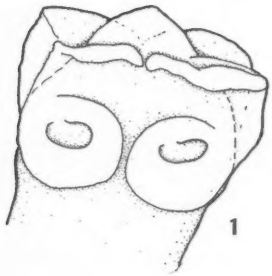
Tetrabothridea Baer, 1954

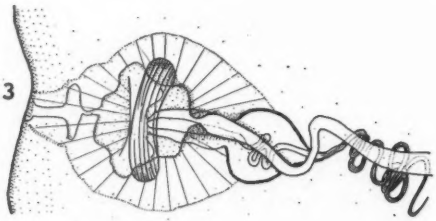
Tetrabothrius cylindraceus (Rudolphi, 1819) (Figs. 1–3)
Host: "Gull" (Charadriiformes), province of Quebec.
Fragments of strobila and detached heads were present.

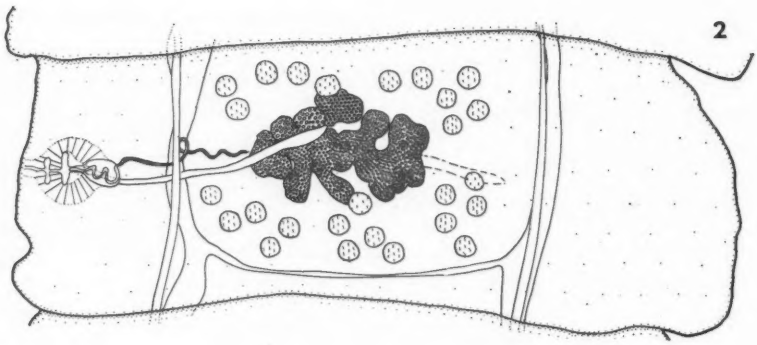
The average diameter of the scolex is 352 μ (Fig. 1). The auricles on the suckers are weakly developed. The testes number about 25 and the cirrus pouch has a diameter of 47 μ (Figs. 2–3). These measurements are in accord with those given by Baer (2).

Characteristic of this genus, the scolex lacks a rostellum, the genital pores are unilateral, and the genital ducts pass between the excretory canals. The cirrus pouch is spherical and the genital atrium is large and muscular. The ovary is extended laterally and is branched; anterior to it lies the vitelline gland. The uterus persists as a lobed sac.

This species is redescribed by Yamaguti (29) and recorded by Wardle (27) from *Larus argentatus* Gm. from Vancouver Island.







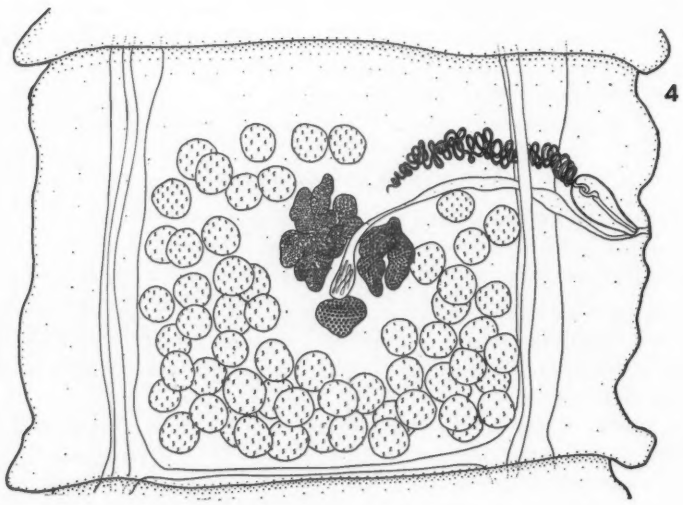


FIG. 1. *Tetrabothrius cylindraceus:* scolex.
FIG. 2. *T. cylindraceus:* dorsal view of mature segment.
FIG. 3. *T. cylindraceus:* dorsal view of genital atrium.
FIG. 4. *Raillietina (Skrjabinia) variabila:* dorsal view of mature segment.

Tetrabothrius erostris (Lönnberg, 1899)

Host: "Gull," province of Quebec.

The specimens were fragmented. The scolex has a diameter of 662 to 850 μ. The auricles on the suckers are well developed and the worm is altogether stouter than *T. cylindraceus*. The testes number about 40 and the cirrus pouch has a diameter of 65 μ. The measurements given by Baer (2) are: scolex 250 to 450 μ, testes 30 to 50, cirrus pouch 59 to 80 μ, average 68 μ. There are no previous records for Canada.

Tetrabothrius immerinus (Abildgaard, 1790)

Hosts: *Gavia immer* (Brünn.) (Gaviiformes), province of Quebec.
Gavia stellata (Pontop.), Cape Smith, Ungava.

The specimens measure 108 to 184 mm. in length with a maximum breadth of 2 mm.

The scolex has a maximum diameter of 940 μ measured across the suckers. The suckers are large and provided with auricles and are 750 μ in length. The neck is 0.7 mm. long.

There are 30 to 40 testes and the cirrus pouch has a diameter of 95 to 131 μ and a length of 95 to 102 μ. The embryos have a diameter of 18 μ.

These measurements are in accord with those given by Baer (2). This is the type species of the genus (syn. *T. macrocephalus* (Rud., 1810) (Baer, 1954)) and is the only one recorded from the Gaviiformes.

Tetrabothrius sp.

Host: *Cephus grylle grylle* (L.) (Charadriiformes), Cape Smith Island.

Only fragments of worms were present. *T. jägerskioldi* Nybelin, 1916 has been reported for this host by Baer (2).

Cyclophyllidea Braun, 1900

Davainea proglottina (Davaine, 1860)

Host: "Grouse" (Galliformes), province of Quebec.

This worm is a common, cosmopolitan parasite of domestic fowl. A key to the species of Davainea occurring in galliform birds is given by Jones (12).

Raillietina (*Skrjabinia*) *cesticillus* (Molin, 1858)

Hosts: *Gallus gallus* L. (Galliformes), Ste. Anne de Bellevue, Que.
"Grouse," province of Quebec.

The specimens are immature with the characteristic cushion-shaped rostellum.

Raillietina (*Skrjabinia*) *variabila* Leigh, 1941 (Fig. 4)

Hosts: *Gallus gallus* L. (Galliformes), St. Hyacinthe, Que.
Idiogenes flagellum (Goeze, 1782) (Figs. 5–6).
Host: *Buteo jamaicensis borealis* (Gm.) (Accipitriformes), Swift Current, Sask.

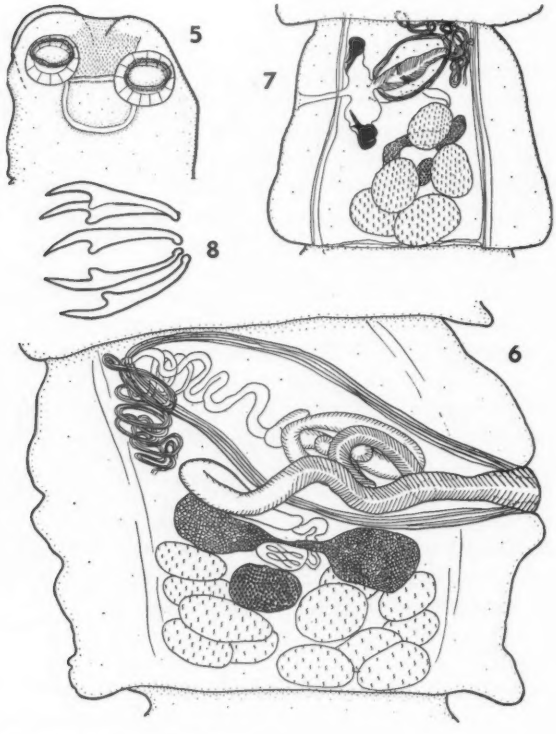


FIG. 5. *Idiogenes flagellum:* scolex.
FIG. 6. *I. flagellum:* ventral view of mature segment.
FIG. 7. *Gryporhynchus tetrorchis:* dorsal view of mature segment.
FIG. 8. *Lateriporus geographicus:* rostellar hooks.

There were about 12 young specimens with scoleces. There were only four ripe segments which showed the horseshoe-shaped uterus characteristic of the genus but in which the paruterine organ had not yet developed.

Mounted in Canada balsam, the scoleces have a diameter of 116 to 171 μ. The suckers, diameter 47 to 58 μ, are armed with small spines (Fig. 5). The rostellum, 55 to 73 μ wide, is armed with about 160 hammer-shaped hooks arranged in a double crown and measuring 7.3 to 8 μ in length. The rostellar sac is provided with a wide collar of minute spines.

The testes number 11 to 14. The cirrus pouch is large (Fig. 6), 360 μ by 95 μ, and extends across the segment to the aporal excretory vessels. The vagina opens at the genital atrium, ventral to the cirrus pouch, and is provided with setae to the middle of its length. The distal portion is sinuous and the proximal part convoluted.

Idiogenes flagellum is the only species of the genus occurring in accipitriform birds and it is the only reported species of the genus with armed suckers.

Fuhrmann in 1906 (5) described this species under the synonym *Davainea* (*Chapmania*) *longicirrhosa*.

The only previous record of the occurrence of this species in North America is by Schultz (25) from *Buteo swainsoni* (Bonap.) from Oklahoma under the synonym *Idiogenes buteonis* Schultz, 1939.

Gryporhynchus tetrorchis Hill, 1941 (Fig. 7)

Host: *Ardea herodias herodias* L. (Ciconiiformes), Montebello, Que.

Several fragments of strobila were present, but there were neither scoleces nor gravid segments.

Typical of this genus are the paired hooks in the genital atrium at the base of the cirrus pouch (Fig. 7). This species has four testes. Hill (9) gives a full description of specimens from *Ardea h. herodias* from Oklahoma. The dimensions of the present specimens and the details of the anatomy agree with the original description.

As reported by Fuhrmann (6) the only records of this genus from North America are those of Ransom (21) and Hill (9).

Lateriporus geographicus Cooper, 1921 (Fig. 8)

Host: *Clangula hiemalis* (L.) (Anseriformes), Bay Ste. Claire, Anticosti Island, Que.

The specimen is 70 mm. long and has a maximum breadth of 2 mm.

The scolex has a diameter of 592 μ mounted in Canada balsam. The round suckers measure 183 μ across and the rostellum has a diameter of 127 μ and a length of 352 μ. The rostellum is armed with 17 to 18 hooks (Fig. 8) arranged in a single crown. The hooks measure 158 to 164 μ by 105 to 113 μ.

The genital pores are unilateral, but for an occasional single segment. There are about 12 testes in each segment and the cirrus pouch measures 352 μ by 70 μ.

This species was originally described from *Somateria mollissima mollissima* (L.) from the Arctic by Cooper (3).

Paruterina candelabraria (Goeze, 1782) (Figs. 9–14)

Hosts: *Aegolis acadicus* (Gm.) (Strigiformes), Canada.
Strix varia varia Barton (Strigiformes), province of Quebec.

The longest worm measures 140 mm. in length and has a maximum breadth of 0.7 mm. The scolex, diameter 183 to 254 μ, has four ovoid suckers measuring 70 to 85 μ by 99 to 141 μ. The rostellum, which is everted in all the specimens, has a diameter of 113 to 141 μ and is armed with 44 hooks arranged in a double crown. The large hooks, mounted in gum chloral (Fig. 9), measure 56 μ by 35 μ and the small ones 44 μ by 33 μ.

The genital pores are irregularly alternating. There are 25 to 26 testes, and the segments show a marked protandry. The cirrus pouch is relatively small, measuring 160 to 182 μ by 58 to 65 μ. The development of the paruterine organ is shown in Figs. 10–13.

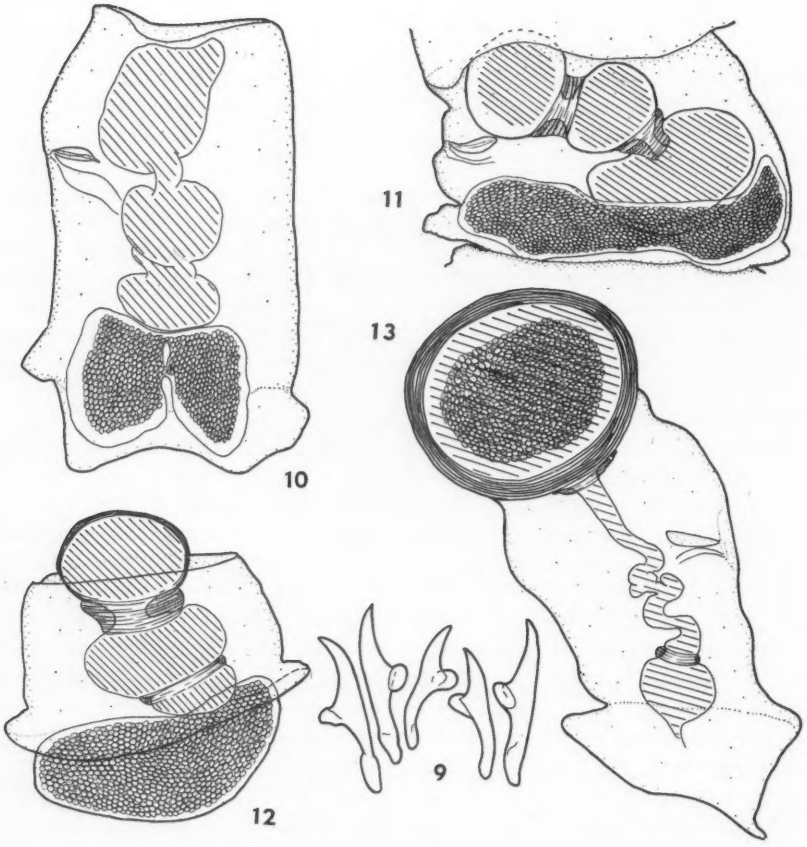


FIG. 9. *Paruterina candelabraria:* rostellar hooks.
FIG. 10. Extended segment showing early development of paruterine organ.
FIG. 11. Segment showing further development of paruterine organ.
FIG. 12. Segment showing later stage in development of paruterine organ.
FIG. 13. Fully gravid, detached segment with eggs in paruterine organ.

P. candelabraria is redescribed by Rausch (22) from North American material, namely, *Bubo v. virginianus* (Gm.) and *Strix v. varia* Barton from the United States. The present material agrees essentially with Rausch's description but for the size of the hooks and the cirrus pouch. Rausch (22) gives 39 to 46 μ as the length of the large hooks and 29 to 34 μ for the small ones. These dimensions are less than those of the present material. Rausch examined European material and found 56 μ and 43 μ as the length of the hooks. Joyeux and Baer (13) give 54 μ and 35 to 37 μ. As Rausch points out, there is considerable variation in this character.

Hübscher (10), describing *P. javanica* from *Hemiprocne longipennis* (Rafinesque) (Cypseliformes) remarks that in the hooks, the rounded portion of the guard is very easily broken off and is frequently missing. This would appear to be the case in Rausch's specimens as seen from his drawing (22, Fig. 3).

This is the first record for Canada.

Rhabdometra odiosa (Leidy, 1887) (Figs. 14–16)

Hosts: *Dendragopus* sp. (Galliformes), British Columbia.
Meleagris galapavo L. (Galliformes), Canada.
"Grouse", British Columbia.

The following description is based on macerated material.

The worm is 130 mm. long and has a maximum breadth of 2 mm. The scolex is large, diameter 451 to 493 μ, and has four unarmed suckers, measuring 211 to 254 μ by 141 to 225 μ, but characteristically lacks a rostellum.

The genital pores are irregularly alternating and open at the anterior third of the lateral margin of the segment. There are 33 to 46 testes posterior and lateral to the ovary (Fig. 14). The cirrus pouch extends past the poral excretory vessels and measures 352 to 493 μ by 70 to 127 μ.

The uterus appears as a spherical sac just posterior to the center of the segment. Anterior to it the paruterine organ (Fig. 15) develops and becomes very twisted in the more contracted specimens (Fig. 16). In no segments were the eggs seen to be enclosed within the paruterine organ. The eggs measure 32 by 25 μ.

This species is described as *Taenia odiosa* by Leidy, 1887 from *Colinus virginianus floridanus* (Coues) from Florida. Jones (11) redescribed Leidy's material. Swales (26) described specimens from *Pedioecetes p. phasianellus* (L.) from Quebec and proposed that *Rhabdometra tomica* Cholodkowsky, 1906, the type species of the genus, from *Lyrurus tetrix* L. from Russia, become a synonym of *R. odiosa*, and *R. odiosa* be considered as the type of the genus. This species is also recorded by Krogsdale (16) from *Lophortyx californica californica* (Shaw) and *Oreortyx picta picta* (Douglas) from California.

Diploposthe laevis (Bloch, 1782)

Host: *Nyroca marila* (L.) (Anseriformes), Canada.

The specimen was incomplete, lacking a scolex. It has a length of 140 mm. and a maximum breadth of 3 mm.

This species is reported from numerous anseriformes including records for North America by Linton (17).

Drepanidotaenia lanceolata (Bloch, 1782) (Fig. 17)

Host: *Chen hyperborea atlantica* Kennard (Anseriformes), province of Quebec.

There was one specimen, lacking a scolex. The length of the strobila is 135 mm. and its maximum breadth is 9 mm.

The genital pores are unilateral. The genital ducts pass dorsal to the excretory vessels. Internal and external seminal vesicles are present. The three testes lie in a straight line across the segment. The female glands are aporal to all three testes (Fig. 17).

This is a common parasite of anseriform birds in Europe and North America.

Echinocotyle rosseteri Blanchard, 1891 (Fig. 18)

Hosts: *Anas discors* L. (Anseriformes), Montreal, Que.
Spatula clypeata (L.) (Anseriformes), Montreal, Que.
Anas crecca carolinensis Gm. (Anseriformes), Montreal, Que.
"Teal", Montreal, Que.

There were several specimens of this small, delicate worm of which the longest was 15 mm., with a maximum breadth of 0.3 mm.

The scolex, with the rostellum everted, has a diameter of 182 to 190 μ. The suckers, measuring 58 by 73 μ, are armed with several rows of spines. The expanded tip of the rostellum has a diameter of 51 μ and is armed with 10 hooks (Fig. 18), measuring 31.5 by 24 μ.

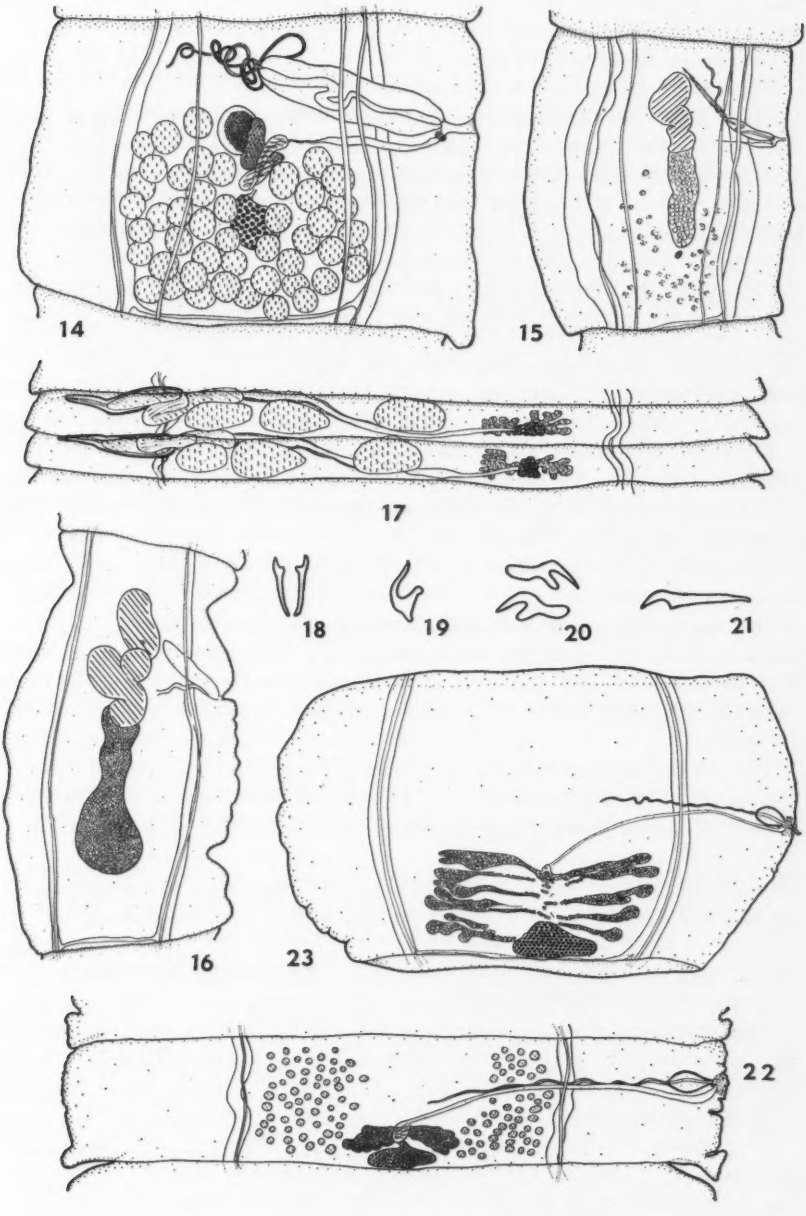
The anatomy is typical of that of *Hymenolepis*. The genus is characterized by 10 rostellar hooks and armed suckers. Schiller (23) considers this genus invalid.

Haploparaxis parafilum Gasowska, 1931 (Fig. 19)

Host: *Erolia alpina sakhalina* (Vieill.) (Charadriiformes), Southampton Island, Hudson's Bay.

There was one young specimen with a scolex.

FIG. 14. *Rhabdometra odiosa:* dorsal view of mature segment.
FIG. 15. Dorsal view of ripening segment.
FIG. 16. Dorsal view of gravid segment.
FIG. 17. *Drepanidotaenia lanceolata:* dorsal view of mature segment.
FIG. 18. *Echinocotyle rosseteri:* rostellar hooks.
FIG. 19. *Haploparaxis parafilum:* rostellar hooks.
FIG. 20. *Hymenolepis furcifera:* rostellar hooks.
FIG. 21. *Hymenolepis multiformis:* rostellar hooks.
FIG. 22. *Cladotaenia foxi:* dorsal view of mature segment.
FIG. 23. *Cladotaenia foxi:* dorsal view of gravid segment.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The scolex has a diameter of 109 μ with four suckers measuring 51 μ across. The partially everted rostellum has a diameter of 40 μ. There are eight rostellar hooks of characteristic shape (Fig. 19) which measure 21 μ by 13.2 μ.

The genital pores are unilateral; there is one testis in each segment; the cirrus pouch is long and extends aporally to the mid-line.

H. parafilum is reported from *Scolopax rusticola* L. and *Scolopax major* (Gm.) from the Ukraine by Gasowska (8): also from *Gallinago* sp. from Somaliland, and from *Scolopax rusticola* L. from southern France by Joyeux and Baer (14). For the latter material the hook length is 24 μ (Joyeux and Baer (13) give 20–24 μ) and the present material agrees in hook shape with this description.

This would seem to be the first record of this species for North America.

A key to the species of *Haploparaxis* is given by Schiller (24).

Hymenolepis furcifera (Krabbe, 1869) (Fig. 20)

Host: *Podilymbus podiceps podiceps* (L.) (Colymbiformes), province of Quebec.

These are delicate worms. The scolex has a diameter of 164 μ to 175 μ, the suckers measure 55 to 58 μ, and the width of the rostellum is 58 to 73 μ. There are 10 rostellar hooks each measuring 26 to 29 μ, the handle being longer than the guard (Fig. 20).

The cirrus pouch measures 160 μ by 21 μ in the mature segments. There were no ripe segments.

The species of *Hymenolepis* occurring in grebes are reviewed by Joyeux and Baer (15) who give a key to these six species. The present material agrees with these authors' description of *H. furcifera*, except that the rostellar hooks are slightly smaller, that is, 26 to 29 μ as against 29 to 38 μ for the Canadian material.

This species was recorded from *Colymbus auritus* L. and *C. grisigena holböllii* (Reinh.) from Massachusetts by Linton (17) under the name of *H. podicepina* Szymanski and this appears to be the only record for North America.

Hymenolepis multiformis (Creplin, 1829) (Fig. 21)

Host: "Pigeon" (? mistake in label. This host is more probably a ciconiiform). Anticosti Island, province of Quebec.

There was one specimen with a scolex but with no gravid segments. The material was very macerated.

The scolex is relatively large, diameter 182 μ, and has four oval suckers which measure 58 μ by 109 μ. The rostellum is partially everted; the rostellar sac measures 146 μ by 73 μ. There are 10 rostellar hooks which are of characteristic shape (Fig. 21) and which have a length of 37 μ.

The anatomy of the strobila is redescribed by Fuhrmann and Baer (7) from specimens from *Sphenorhynchus abdimii* (Licht.) from Ethiopia. The scolex has been described by the writer (18) from specimens from a swan from the Belgian Congo.

This species occurs typically in the ciconiiformes and it is most unlikely that the host is in fact a pigeon.

There is no previous record for North America.

Cladotaenia foxi McIntosh, 1940 (Figs. 22–23)

Hosts: *Falco peregrinus anatum* Bonap. (Accipitriformes), Dundas Harbour, Devon Island, N.W.T.

Falco rusticolus obsoletus Gm., Anticosti Island, Que.

Falco sp., Wolstenholme, Hudson's Bay.

The material comprised several scoleces, all of which had lost their hooks, and some portions of strobila. The material was macerated.

The length was estimated at 70 mm. The maximum breadth is 2 mm.

The scolex has a diameter of 255 μ, the suckers measure 84 μ by 120 μ, and the rostellum is 88 μ wide.

The genital pores are irregularly alternating and the genital ducts pass between the excretory vessels. The testes number 105 to 115. They are disposed in two lateral fields (Fig. 22) and on the poral side they are situated both anterior and posterior to the genital ducts. There are no testes behind the female organs. The cirrus pouch measures 73 to 109 μ by 34 to 72 μ. The uterus is posterior in position (Fig. 23). It is short and does not extend forward to the level of the genital pore. There are seven to eight lateral uterine branches.

In 1946 Crozier (4) listed the species of this genus (and the relevant bibliography), with the exception of *C. melierax* (Woodland, 1929) from *Melierax gaber* (Daud.) from the Sudan, which Fuhrmann and Baer (7) in 1943 transferred to the genus *Cladotaenia*. Preble (20) found specimens of *C. foxi* in *Falco peregrinus anatum* Bonap. from Ohio.

Progynotaenia americana Webster, 1951

Host: *Pluvialis dominica dominica* (Müll.) (Charadriiformes), Ile Perrot, Que.

There were two specimens with scoleces, both of which had lost their hooks. The material was poorly fixed and it was difficult to distinguish the internal anatomy.

These are very small worms, only 2.5 mm. long, and composed of few segments. The genital pores are irregularly alternating.

The scolex has a diameter of 182 to 212 μ. The suckers measure 87 by 102 μ. The rostellum is well developed and when everted its maximum diameter is 58 to 73 μ. Although the hooks have been lost, it is possible to make out a ring of small projecting scars which are presumably the points of attachment of the hooks. These are 12 in number.

The cirrus pouch is large and when the cirrus is everted the pouch is contained in a papilla on the lateral margin of the segment. The maximum

TABLE I

Progynotaenia SPECIES

Species	*P. jägerskioldi*	*P. evaginata*	*P. americana*	*P. odhneri*	Canadian material
Length	2–2.5 mm.	2.3 mm.	1–3 mm.	2–3 mm.	2.5 mm.
Breadth	—	0.67 mm.	—	0.5–1.07 mm.	—
No. segments	10–14	17	13	8–14	—
Scolex	240–280 μ	328–336 μ	185–351 μ	240–350 μ	182–212 μ
Suckers	100 μ	180–220 × 144 μ	82–136 μ	150–320 μ	87 × 102 μ
Rostellum	13 (130?) μ	288–360 × 126 μ	49–127 μ	70–82 × 100–325 μ	58–73 μ
No. hooks	29–34	18	12–14	12–18	12
Hook length	59 μ	55–60 μ	57–75 μ	50–75 μ	—
Testes No.	18–20	20–22	8–15	15–18	—
Cirrus pouch	240 μ	800 μ	153–360 × 53–71 μ	200–360 × 75–120 μ	314 × 124 μ
Eggs	—	—	29–32 × 23–28 μ	—	44 μ
Onchosphere	28 μ	—	17–19 × 15–17 μ	—	18 × 25 μ
Embryo	—	—	—	—	15 × 22 μ
Host	*Pluvianus a. aegypticus*	*Burhinus s. senegalensis*	*Charadrius melodus* *C. hiaticula semipalpatus* *Crocetha alba* *Charadrius vociferus*	Type: *Charadrius hiaticula* (Sweden) *Tringa totanus* (Marseille) *Charadrius alexandrinus* (Tunisia)	*Pluvialis d. dominica*
Locality	White Nile	White Nile	North America	—	Quebec

Abbreviations used in table: *Breadth: maximum breadth of strobila; cirrus pouch: maximum length and maximum breadth of cirrus pouch; egg: diameter of eggs; embryo: diameter of embryo; hook length: length of rostellar hook; length: length of longest specimen; No. hooks: number of rostellar hooks; onchosphere: diameter of onchosphere; rostellum: diameter of rostellum; scolex: diameter of scolex measured across the suckers; suckers: diameter of suckers; testes: number of testes per segment.*

size of the cirrus pouch in the present specimens is 314 μ by 124 μ. The cirrus is heavily spined.

It was impossible to determine the number of testes or the arrangement of the female organs. There was one segment containing ripe eggs. The wide outer shell has a diameter of 44 μ, the onchosphere of 18 μ by 25 μ, and the embryo of 15 μ by 22 μ.

All the species so far reported for this genus are found in charadriiformes. The genus is revised by Baer (1), who lists three valid species: *Progynotaenia jägerskioldi* Fuhrmann, 1909; *Progynotaenia evaginata* Fuhrmann, 1909 (syn. *Progynotaenia pauciannulata* Baczynska, 1914 partim.); and thirdly, *Progynotaenia odhneri* Nybelin, 1914 (syn. *P. pauciannulata* partim. and *P. foetida* Meggitt, 1928).

Webster (28) describes a new species, *P. americana* from *Charadrius melodus* Ord., *Crocethia alba* (Pall.), and *Charadrius hiaticula semipalpatus* Bonap. from Texas, and *Charadrius vociferous* L. from Texas and Michigan. Webster considers *P. foetida* and *Progynotaenia* sp. Joyeux and Baer (1939) to be specifically distinct.

Table I compares the measurements for *P. jägerskioldi*, *P. evaginata*, *P. americana*, and *P. odhneri*, together with those of the present material. As may be seen from the table, the Canadian material agrees most closely with *P. americana*. It is highly likely, however, that *P. americana* is identical with *P. odhneri*, since from the measurements given, the former differs from the latter only in the size of the scolex and the slightly smaller number of testes. Unfortunately, it was not possible to discern the number of testes in the present material, and thus to know whether this form has an intermediate number of testes. For the moment then, it is preferable to record this worm as *P. americana* Webster, 1951.

Tatria biremis Kowalewski, 1904

Host: *Podilymbus podiceps podiceps* (L.) (Colymbiformes), province of Quebec.

There was one complete specimen. The worm is tiny, 3 mm. long and 0.35 mm. wide. There are 19 segments. The genital pores are regularly alternating. The segments have the typical, posteriorly-directed prolongations of the lateral borders of the segments.

The scolex has a diameter of 299 μ. The suckers are large, measuring 160 μ by 116 μ, and the rostellum, which is partially everted, has a diameter of 57 μ. The rostellar sac measures 73 μ across its widest part and 226 μ in length. There are 10 rostellar hooks measuring 43.7 μ in length.

The testes are large and number 10 to 12. The cirrus pouch, containing an armed cirrus, measures 84 by 36 μ in a mature segment, attaining 120 μ by 44 μ in the fourth from last proglottid.

In the last four segments, the spherical uterus occupies the whole medulla. The eggs, which are not enclosed in capsules, measure 18 μ in diameter.

Host List

AVES

GAVIIFORMES	
Gavia immer (Brünn.)	*Tetrabothrius immerinus* (Abildgaard, 1790)
Gavia stellata (Pontoppiden)	*T. immerinus* (Abildgaard, 1790)
"Arctic diver"	*Ligula intestinalis* (Lin., 1758)
COLYMBIFORMES	
Podilymbus podiceps podiceps (L.)	*Hymenolepis furcifera* (Krabbe, 1869)
	Tatria biremis Kowalewski, 1904
CICONIIFORMES	
Ardea herodias herodias L.	*Gryporhynchus tetrorchis* Hill, 1941
ANSERIFORMES	
Anas crecca carolinensis Gm.	*Echinocotyle rosseteri* Blanchard, 1891
Anas discors L.	*E. rosseteri* Blanchard, 1891
Chen hyperborea atlantica Kennard	*Drepanidotaenia lanceolata* (Bloch, 1782)
Clangula hiemalis (L.)	*Lateriporus geographicus* Cooper, 1921
Mergus merganser americanus (Cassin)	*Ligula intestinalis* (Lin., 1758)
Nyroca marila (L.)	*Diploposthe laevis* (Bloch, 1782)
Spatula clypeata (L.)	*Echinocotyle rosseteri* Blanchard, 1891
"Teal"	*E. rosseteri* Blanchard, 1891
ACCIPITRIFORMES	
Buteo jamaicensis borealis (Gm.)	*Idiogenes flagellum* (Goeze, 1782)
Falco peregrinus anatum Bonap.	*Cladotaenia foxi* McIntosh, 1940
Falco rusticolus obsoletus Gm.	*C. foxi* McIntosh, 1940
Falco sp.	*C. foxi* McIntosh, 1940
GALLIFORMES	
Dendragopus sp.	*Rhabdometra odiosa* (Leidy, 1887)
Gallus gallus L.	*Raillietina (Skrjabinia) cesticillus* (Molin, 1858)
	R. (S.) variabila Leigh, 1941
Meleagris galapavo L.	*Rhabdometra odiosa* (Leidy, 1887)
"Grouse"	*Davainea proglottina* (Davaine, 1860)
	Raillietina (Skrjabinia) variabila Leigh, 1941
	Rhabdometra odiosa (Leidy, 1887)
Galliform	*Davainea proglottina* (Davaine, 1860)
	Raillietina (Skrjabinia) cesticillus (Molin, 1858)
CHARADRIIFORMES	
Cephus grylle grylle (L.)	*Tetrabothrius* sp.
Erolia alpina sakhalina (Vieill.)	*Haploparaxis parafilum* Gasowska, 1931
Pluvialis dominica dominica (Müll.)	*Progynotaenia americana* Webster, 1951
"Gull"	*Tetrabothrius cylindraceus* (Rudolphi, 1819)
	Tetrabothrius erostris (Lönnberg, 1889)
COLUMBIFORMES	
? *Columba livia livia* Gm.	*Hymenolepis multiformis* (Creplin, 1829)
STRIGIFORMES	
Aegolius acadicus (Gm.)	*Paruterina candelabraria* (Goeze, 1782)
Strix varia varia Barton	*P. candelabraria* (Goeze, 1782)

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A REVISION OF THE NEARCTIC CTENISCINI (HYMENOPTERA: ICHNEUMONIDAE)

II. ACROTOMUS HLGR. AND SMICROPLECTRUS THOM.[1]

By W. R. M. Mason[2]

Abstract

The genus *Acrotomus* and its one Nearctic species and *Smicroplectrus* and its 12 Nearctic species and subspecies are discussed. Four new species and one subspecies are described. One species is synonymized, and one is reduced to a subspecies of a Palaearctic species.

Acrotomus Holmgren

Acrotomus Holmgren, 1858. Svensk. Vet.-Akad. Handl. 1 : 222.

Type: *Tryphon lucidulus* Grav., Var. II, Holmgr. Included by Woldstedt in *Delotomus*, q.v.

Delotomus Foerster, 1868. Verhandl. naturh. Ver. Preuss. Rheinlande, 25 : 194 (new name for *Acrotomus* Holmgren).

Type: *Tryphon lucidulus* Gravenhorst, Var. II, Holmgren. Included by Woldstedt, 1877, Bull. Acad. Sci. St. Petersbourgh, 23 : 455.

This genus may be distinguished from all other Nearctic Cteniscini by the mandibles, which have the lower tooth larger and longer than the upper.

The single Nearctic species appears to be closely related to the more primitive species of *Cteniscus*, having a similar ovipositor and subgenital plate. The genus *Anisoctenion* (of authors, not of the genotype)[3] is very closely related to, or perhaps congeneric with, the Nearctic species. The *Acrotomus–Anisoctenion* (auct.) group is almost entirely Palaearctic and Oriental, and known to me from only a few old specimens. The group is treated here as a single genus of diverse character but may well be divisible into several genera when more knowledge of the oriental fauna is available. Also closely related is the genus *Orthomiscus*.

Acrotomus ornatus (Walsh)

Exenteron [!] *ornatus* Walsh, 1873, Trans. Acad. Sci. St. Louis, 3 : 105 (o.d., ♂, no locality given; type destroyed).

Cteniscus rufus Provancher, 1876, Naturaliste can. 8 : 318 (o.d., ♀, Que.; type in MPQ).

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[3]*The eggs of T. alacer Grav. were figured by Clausen, 1932, Proc. Entomol. Soc. Washington, 34 : 49-60. They appear to be of the form typical of the genus Cteniscus. An examination of an egg-bearing female determined by Mr. G. J. Kerrich of the British Museum confirmed Clausen's discovery and added the evidence that the ovipositor form, too, is that typical of Cteniscus.*

Acrotomus rufus (Provancher) Davis, 1894, Proc. Acad. Nat. Sci. Phila. p. 190 (Syn.).

Delotomus rufus (Provancher) Davis, 1897, Trans. Am. Entomol. Soc. 24 : 227 (Syn.).

Diaborus ornatus (Walsh) Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (key des., syn., ♂, Ill., misdet.).

Cteniscus ornatus (Walsh) Townes, 1944, Mem. Am. Entomol. Soc. 11 : 163 (syn., misdet. in part).

There is only one Nearctic species in this genus; it is more constant than most Cteniscini in morphology, but more variable in color. Many of the references to this species are based on misidentifications.

The identity of Walsh's species has been a source of uncertainty but can be best clarified as follows. The very detailed account of the petiole and general coloration eliminates all cteniscines but *Acrotomus rufus* (Prov.) and a few red-bodied species of *Eudiaborus*. Walsh carefully notes the "very fine, sparse punctures" on the head, thorax, and abdomen. It is evident from other descriptions by Walsh that this means punctures which are near the limit of visibility of a 10-power hand lens. Only *A. rufus* (Prov.) has coarse enough punctures to answer this requirement. Walsh's rather exact description did not mention the characteristic abdominal aciculations but these are occasionally absent.

This species is distinguished from any other *Acrotomus* known to me by its short, auriculate petiole, flat subgenital plate, and strongly longitudinally aciculate basal abdominal tergites. It cannot be confused with any Nearctic cteniscine if the mandibles are examined, and the strong longitudinal aciculation is a further unique feature.

Mr. G. J. Kerrich of the British Museum, who has made an intensive study of the Palaearctic Cteniscini, has kindly examined four specimens of this species, and (in litt.) considers it a generalized member of the genus *Anisoctenion* Foerster, falling not far from *Exyston pratorum* (Woldstedt).

Neotype

Male; length 4.5 mm.; head slightly wider than thorax; eyes large and prominent, about as wide as temples, which converge behind at about 30°; clypeus convex and oval, about 1.5 times as wide as long, its surface smooth with a few scattered coarse punctures, divided from the face by a sharp sulcus; face coarsely and densely punctate centrally, less punctate laterally and on the median line; cheek, temple, and vertex coarsely but not densely punctate; occipital and hypostomal carinae distinct, complete, and meeting well above the mandibular articulation, but nowhere strongly elevated; antenna slightly shorter than body.

Pronotum and mesonotum finely and moderately densely punctate; mesopleuron moderately coarsely and densely punctate; mesonotal flange and axillary tongue strongly developed and vertical; propodeum rounded, slightly rugulose, and fully carinated; areola keystone-shaped, a little longer than

wide. Veins of wing dark brown; areolet obliquely rhomboidal, subpetiolate; second recurrent vein with two bullae. Legs of normal proportions but hind coxa unusually stout; tarsal claws pectinate with two basal teeth.

Abdomen short and broad; the petiole strongly auriculate, 1.45 times as long as wide apically and 1.4 times as wide apically as basally; first and second tergites and base of third, longitudinally aciculate, remainder of tergites finely punctate.

Head and thorax black with the following parts yellow: mouth parts, clypeus, face, inner orbit to slightly above antenna, cheek, propleuron upper margin and lower lateral margin of pronotum very broadly, tegula, subtegular ridge, scutellum, and postscutellum. Antenna reddish except lower halves of scape and pedicel yellow. Legs red with yellow coxae and trochanters; four anterior legs much infused with yellow basally; hind coxa red below. Abdomen red, the first tergite black except for a pale red lunate apical area; basolateral parts of second tergite dusky.

Neoallotype

Female; resembling the neotype except in the following details: length 5.5 mm., propodeal longitudinal carinae weak in the second areas, petiole of broader proportions, subgenital plate broad and flat with apex rounded-acute, third valvula strongly evenly tapered and rounded apically, first valvula deep but tapered only at the apex and bearing an elliptical hyaline area and apical teeth, second valvula thick and blunt apically in lateral view but strongly tapered in dorsal view, ovipositor gently decurved throughout its length (Fig. 1).

Color like that of the male with the following differences: propleuron broadly black medially and anteriorly, yellow margins of pronotum less broad, legs deeper red and four anterior coxae reddish basally, a larger area of red on the petiolar apex, glimma red.

Egg

Broadly ovate-reniform with short, thick, posteroventral stalk; foot broad, oval, and large, extending dorsally to top of egg and beyond middle of egg anteriorly; foot reinforced by two parallel thickenings which meet posteriorly and diverge at anterior apex; anterior 0.7 of egg shell reticulately sculptured; anterior apex of egg bearing a low vertical ridge (Figs. 2, 3).

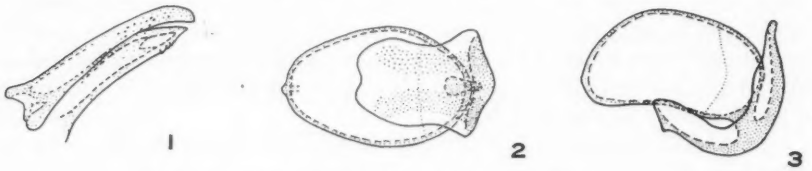


FIG. 1. *Acrotomus ornatus* (Walsh), ovipositor.
FIG. 2. *A. ornatus* (Walsh), egg, ventral view.
FIG. 3. *A. ornatus* (Walsh), egg, lateral view.

Variation

Males.—Length 2.5 to 6.5 mm.; propodeum sometimes almost completely smooth; areola up to twice as long as wide; tarsal claws with one to three basal teeth; petiole 1.3 to 1.5 times as long as wide apically and 1.3 to 1.5 times as wide apically as basally; occasionally basal tergites scarcely aciculate, but apically or entirely smooth. Ground color of the thorax sometimes red, the medial dorsal and ventral areas remaining darkest. Abdomen varying from entirely red to entirely black or dark brown with the apical margins of the anterior tergites pale red. Yellow of the pronotum sometimes reduced to a narrow lower margin and the corner adjacent to the tegula. Propleuron usually red to black above. Hind coxa varying from entirely red to entirely yellow.

Females.—Length 4.5 to 6.5 mm.; areola up to twice as long as wide; median longitudinal carinae of propodeum sometimes absent; subgenital plate often gently folded about the mid-line, but never with a sharp median crease. Ground color of the thorax sometimes red, but usually entirely black. Abdomen sometimes entirely red or with the anterior tergites darkened basally. Hind coxa usually entirely red.

Specimens Seen (31 ♂ ♂, 26 ♀ ♀)

Neotype.—Male, Farmingdale, New York, June 16, 1936, Blanton & Borders (Townes).

Neoallotype.—Female, same data as above (Townes).

Other specimens.—ONT.: ♂, Bell's Corners, June 24, 1937, G. S. Walley, (CNC); ♀, Bowmanville, Aug. 1, 1913, W. A. Ross, (CNC); ♀, Constance Bay, July 10, 1933, G. S. Walley, (CNC); ♂, Constance Bay, July 8, 1935, F. A. Urquhart, (CNC); ♂, Mer Bleue, Ottawa, June 22, 1919, (CNC); ♀, Pt. Pins, L.S. (near Sault Ste. Marie ?) July 24, (USNM); 3 ♀ ♀, Rockcliffe, Ottawa, July 26, 1946, A. R. Brooks, (CNC); ♂, Toronto, Sept. 30, 1896, D. G. Cox, Baker No. 2039, (USNM). QUE.: ♂, ♀, Kazabazua, June 29, 1933, G. S. Walley, (CNC); ♀, Montreal, June 15, (CU). N.B.: 2 ♂ ♂, Tabusintac, July 20, 1939, W. J. Brown, (CNC). N.S.: ♂, Truro, July 31, 1919, R. Matheson, (CU). MICH.: ♂, Clare Co., July 11, 1942, R. R. Dreisbach, (Dreisbach); ♀, Douglas Lake, Aug. 14, 1925, H. B. Hungerford, (Kans.); ♂, Cheboygan Co., July 13, 1940, R. I. Salter, (Kans.); ♀, Kalkaska Co., July 8, 1939, R. R. Dreisbach, (Dreisbach); ♀, Mackinaw Co., Aug. 24, 1940, R. R. Dreisbach, (Dreisbach); ♂, Midland Co., July 18, 1940, R. R. Dreisbach, (Dreisbach); ♀, Midland Co., Sept. 15, 1945, R. R. Dreisbach, (Townes); ♂, Rosscommon Co., July 9, 1945, R. R. Dreisbach, (Townes); ♂, Saginaw Co., July 16, 1939, R. R. Dreisbach, (Dreisbach). N.Y.: 2 ♂ ♂, Oswego, July 1, 1897, (USNM); 11 ♂ ♂, 5 ♀ ♀, Farmingdale, June 6–16, 1936, Blanton & Borders, (Townes, CU, Oreg.); ♂, 6 ♀ ♀, Farmingdale, July 4–16, 1938, H. & M. Townes, (Townes). MAINE: ♂, Machias, July 22, (MCZ). N.H.: ♀, Stinson Lake, Aug. 6, 1945, J. C. Bradley, (CU). CONN.: ♂, Lyme, July 1, 1918, W. S. Fisher, (USNM).

S.C.: ♀, McClellanville, May 20, 1944, H. K. Townes, (Townes). GA.: ♂, Thunderbolt Savannah, Apr. 21, 1911, (CU). FLA.: ♀, Silver Springs, Apr. 29, 1928, (CU).

This species ranges from the Austro-riparian Zone to the southern fringes of the Canadian Zone. No differences between southern and northern specimens can be seen.

The males appear from April in the South to July in the North. Females live until late summer in the North.

Smicroplectrus Thomson

Microplectron Foerster, 1868. Verhandl. naturh. Ver. Preuss. Rheinlande, 25 : 195. Preoccupied.

Type: *Exenterus jucundus* Holmgren. Designated by Viereck, 1914, U.S. Natl. Museum Bull. No. 83 : 95.

Smicroplectrus Thomson, 1883. Opuscula Entomol. 9 : 888.

Type: *Exenterus jucundus* Holmgren. Designated by Viereck, 1912, Proc. Entomol. Soc. Washington, 14 : 177.

Anderis Davis, 1897. Trans. Am. Entomol. Soc. 24 : 233.

Type: *Cteniscus albilineatus* Walsh. Designated by Viereck, 1914, U.S. Natl. Museum Bull. No. 83 : 10.

Excavarus Davis, 1897. Trans. Am. Entomol. Soc. 24 : 233.

Type: *Cteniscus annulipes* Cresson. Designated by Viereck, 1914, U.S. Natl. Museum Bull No. 83 : 58.

Auderis Davis, 1898. Trans. Am. Entomol. Soc. 24 : 348. Emendation of *Anderis* Davis.

The synonymy of the genera has been adequately discussed by Walley, 1937.

Nearctic members of the genus are quickly distinguished by the combination of short, basally auriculate, petiole and modified subtegular ridge (Part I, Figs. 2, 3, 4) and strongly developed propodeal carinae.

The closest relative of this genus is *Exyston* Schiodte. The two genera are readily distinguished in the Nearctic region, but in the Old World grade into one another so that careful examination of a combination of characters is needed to place individuals. This genus shares a number of characters in common with *Exyston*, the more notable of which are: piliferous cenchrilike lobes on the metanotum, modified subtegular ridge, frequent presence of small spurlike projections at the apex of the hind tibiae, auriculate petiole, strongly arched abdominal tergites, reduced subgenital plate and ovipositor, usually pyriform egg with terminal stalk. It is evident from the absence of spurlike projections at the apex of the hind tibiae and from the nature of the subtegular ridge of the *annulipes* group that it is most closely related to *Exyston*.

The Nearctic species fall naturally into three groups. The first of these is the *annulipes* group and includes the species *annulipes* (Cress.), *velox* Wly.,

etrocaulus n. sp., and probably the Palaearctic *sibiricus* Kerr. This group is distinguished by the double form of the subtegular ridge similar to that of *Exyston*, and the absence of a spurlike projection at the apex of the hind tibia. The second group is the *incompletus* group. It includes the Nearctic species *incompletus* Walley, *walleyi* n. sp., and *eburneus* n. sp., and is characterized by the absence of the lateral longitudinal carinae on the propodeum and their replacement by a smooth shining area. The third group is the *jucundus* group and includes the Nearctic species *robustus* Walley, *apicatus* (Prov.), *californicus* (Cress.), *takomae* n. sp., the Holarctic *jucundus* (Holgr.), and all the Palaearctic species known to me. This group is characterized by the presence of spurlike projections at the apex of the hind tibiae and by the subtegular ridge being produced upward to meet the tegula and not doubled posteriorly, characters shared with the second group; in addition the propodeum is more or less fully carinated.

Head transverse; clypeus one-third to one-half as long as wide; inner margins of eyes divergent below, rarely subparallel in the male; malar space less than the width of the base of the mandible; temple in lateral view equal to the width of the eye, not expanded behind the eye; hypostomal carina complete, expanded below the junction with the occipital carina in three species only; occipital carina never expanded, often weak or obsolescent near its junction with the hypostomal carina.

Mesonotal grooves present, extending about one-third of the full length of the mesonotum; mesonotal flange and axillary tongue well-developed; subtegular ridge produced upward to meet the tegula or doubled posteriorly; prepectal carina in the *annulipes* group turning under the pronotum at its lower corner or, in the *jucundus* and *incompletus* groups staying remote from the pronotum and continuing upward; propodeum short or long, its carinae strong, especially the apical; sometimes lateral longitudinal carina and costulae lost completely; hind tibiae with a small apical projection (absent in *annulipes* group); tarsal claws pectinate with three to eight teeth.

Petiole auriculate, the lateral and dorsal carinae strong and usually percurrent, 1.0 to 1.8 times as long as its apical width, but little wider at the apex than at the base; basal tergites usually rugose, apical ones polished and punctate; tergites constricted on the basal half and the apical ones strongly arched; subgenital plate reduced and weakly sclerotized; ovipositor short, gradually tapered from the middle to a sharp point, often thickest at the middle; third valvulae vomeriform, i.e., hollowed and spatulately expanded in the apicoventral area.

The ground color of the genus is black, often replaced by red, especially in more southerly specimens. A yellow pigment is present in an almost universal pattern as follows: mouth parts, clypeus, face, cheek, lower part of the antennal base, tegula, subtegular ridge, scutellum, postscutellum, four anterior coxae and more or less of the remainder of the legs, ventral surface of the abdomen, a narrow apical band on each tergite, sides of the posterior tergites, genitalia.

Egg is usually ovate-pyriform with apical stalk and small anchor, but sometimes ovate with a ventral stalk.

The genus *Smicroplectrus* is found throughout the boreal coniferous and temperate deciduous forests of the Old and New Worlds. In North America it extends north to timberline and beyond that into the bush tundra of Alaska. The genus has been taken as far south as eastern Texas and southern California.

Most North American species of *Smicroplectrus* have been reared from time to time from unidentified larvae of Tenthredinidae on both coniferous and deciduous trees. The identified hosts are in *Pteronidea*. Some species have been observed to insert the stalk of their eggs in the prothoracic region of the host larvae. Overwintering, as far as known, is within the cocoon of the hosts. The adults emerge in spring or early summer, and frequently pass more than one generation during the summer in more southerly regions, although the more boreal species have only one generation per year.

KEY TO *Smicroplectrus*

1. Hind tibia with a small, immovable, apical spine, no longer than the width of the tibia; subtegular ridge single posteriorly, produced upward to meet the tegula in closed position (I, Fig. 3) 4
   Hind tibia without any apical spine; subtegular ridge double posteriorly, not produced upward (I, Fig. 4) 2

2. Hind tarsal claws with three to four small teeth on the basal 0.4; egg with a simple terminal stalk but without granular sculpture; hind tibia with a dirty yellowish annulus; thorax rarely red ..... *velox* Walley
   Hind tarsal claw with four to six teeth on the basal 0.7; egg either with a ventral stalk or granular; hind tibia with a white annulus; lower parts of thorax extensively red 3

3. Prepectal carina curving inward behind the pronotum, with no vertical branch; ovipositor straight or curved up; egg large and granular, bearing a terminal stalk with a large basal lobe; base of hind femur dark ..... *annulipes* (Cress.)
   Prepectal carina as above, but with a vertical branch in addition; ovipositor strongly decurved; egg small and smooth, with a short ventral stalk; base of hind femur red ..... *etrocaulus* n. sp.

4. Lateral longitudinal carinae and costulae of propodeum completely absent, their place smooth and polished 5
   Lateral longitudinal carinae and costulae of propodeum present, though sometimes weak 7

5. Egg stalk with no basal swelling; temples but weakly convergent behind eyes (10° to 30°); mesonotal flanges convergent and not widened behind (Fig. 5); axillary tongue as wide as or wider than long; pleura and prepectus black ..... *incompletus* Walley
   Egg stalk with a basal swelling; temples strongly convergent behind eyes (30° to 60°); mesonotal flanges parallel and widened behind (Fig. 4); axillary tongue longer than wide and incurved; pleura red or yellow; prepectus yellow 6

6. Nervulus interstitial; hind coxa yellow; pleura extensively yellow, not red; hind tibia yellow behind ..... *eburneus* n. sp.
   Nervulus postfurcal; hind coxa red; pleura often extensively red; hind tibia black ..... *walleyi* n. sp.

7. Egg stalk apical, often with a basal lobe or enlargement; hind tarsi incrassate, the basitarsus in lateral view four to five times as long as wide, and fusiform (Fig. 12) 8
   Egg stalk apical or ventral, but with no basal enlargement; hind tarsi normally developed, in lateral view five to nine times as long as wide, and cylindrical (Fig. 11) 9

8. Egg stalk with a large, transverse, palmately lobed enlargement (Fig. 14); hind coxa black, or yellow and black ..... *apicatus* (Prov.)
   Egg stalk with smaller flat lateral expansions (Fig. 15), which are reduced on stretching of the stalk; hind coxa red ..... *robustus* Walley

9. Median longitudinal carinae of propodeum high and arched; profile of propodeum bent at the middle of the areola; costula strong (Fig. 8); head of normal shape, cheek rounded (Fig. 6); hind coxa and often much of the body red.....*californicus* (Cress.)
Median longitudinal carinae of the propodeum low; profile of propodeum bent at the apical carina; costula weak or absent (Fig. 9); temple strongly bulging at the top, the cheek flattened and receding (Fig. 7); hind coxa black, or black and yellow; body never red.....10

10. Egg stalk terminal (Fig. 17); ovipositor curved upward; costula usually completely absent; antenna of male 23- to 28-segmented; length of male up to 8 mm., of female up to 9.5 mm.; from a vertical view temples converging behind eyes at 30° to 45°; male prepectus black within range of *takomae*; circumpolar in distribution.....*jucundus albilineatus* (Walsh)
Egg stalk ventral (Fig. 18); ovipositor decurved; costula usually present, though often weak or incomplete; antenna of male 21- to 23-segmented; length of male less than 6 mm., of female less than 6.5 mm.; temples convergent behind eyes at 20° to 30°; male prepectus black or yellow; not known in eastern North America.....*takomae* n. sp.

Smicroplectrus jucundus (Holmgren)

Exenterus jucundus Holmgren, 1858, Svensk. Vet.-Akad. Handl. 1 : 227 (o.d., ♂, ♀, Swedish Lapland).

This species is closely related to *S. californicus* and may be distinguished from it by the key characters. In the Nearctic Region the black and yellow, or black, hind coxae are the best distinguishing feature.

The typical subspecies occurs in the Palaearctic Region. Distinctions between this subspecies and the Nearctic subspecies are discussed under the latter.

Smicroplectrus jucundus albilineatus (Walsh)

Cteniscus albilineatus Walsh, 1873, Trans. Acad. Sci. St. Louis, 3 : 107 (o.d., ♀, locality unknown, type destroyed).

Anderis albilineatus (Walsh), Davis, 1897, Trans. Am. Entomol. Soc. 24 : 234 (key, syn., des., Canada, Colo., Ill., Mich., in part).

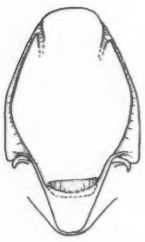
Auderis albilineatus (Walsh), Davis, 1898, Trans. Am. Entomol. Soc. 24 : 348 (Syn.).

Microplectron albilineatum (Walsh), Cushman, 1928, Mem. Cornell Univ. Agr. Expt. Sta. 101 : 948 (N.Y.).

Smicroplectrus albilineatus (Walsh), Walley, 1937, Can. Entomologist, 69 : 136 (key, syn., des., Ont.).

This subspecies is reduced to its present category after comparison of Nearctic with Palaearctic specimens and consultation with G. J. Kerrich of the British Museum. It is evident from Walsh's reference to yellow "prosternum" that his type was a female, not a male.

It may be distinguished from the Palaearctic subspecies by the following characters: propodeum longer and slimmer and with the apical carina more strongly dentate, hind femora rarely red (usually red in Europe and California), inner orbits rarely extending above eyes and detached spots very small if present (in European specimens inner orbits usually extending above eyes and detached spots large), apical half of antenna black or at least brown above and rarely yellow in the female (in European forms apical half of antenna yellow in the female and dark above in the male).



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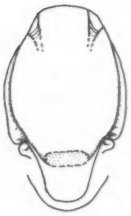

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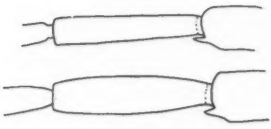

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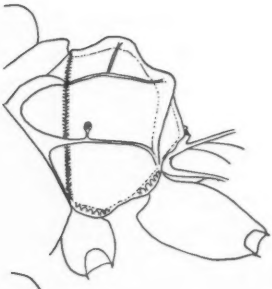

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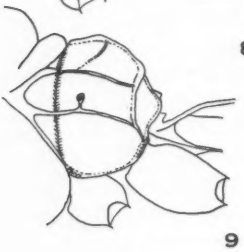

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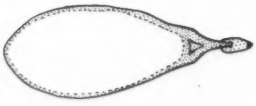

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Neotype

Female; length 7 mm.; clypeal suture weakly defined; temples convergent behind eyes at 40°; cheek and temple below flattened and receding; temple strongly swollen at upper end, vertical region elevated (Fig. 7); hypostomal carina about one-fifth as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at a right angle, obsolescent at point of junction; antenna scarcely attenuate toward apex, 25-segmented.

Prepectal carina vertical, without a branch curving under pronotum; sternaulix shallow; mesonotal flange and axillary tongue well-developed; subtegular ridge projecting upward to meet tegula when in closed position; mesopleuron polished and punctate, speculum occupying upper posterior quarter; scutellum convex, polished, sparsely punctate; propodeum longer than high, shining and sparsely verrucate; propodeal carinae strong, apical carina strongly dentate, costulae completely missing; middle and hind tarsal claws pectinate with three to four large teeth; hind tibia spurred; length of hind basitarsus seven times width in lateral view, cylindrical.

Length of petiole 1.4 times apical width; petiole strongly rugulose behind; second tergite and base of third and fourth tergites rugulose, remainder of tergites shining and finely punctate; ovipositor curved slightly upward and tapered in its apical third (Fig. 17).

Color black, the following parts yellow: mouth parts, clypeus, face, cheek and postocciput to one-quarter eye-height, scape below, propleuron, upper and lower margins of pronotum laterally, prepectus, tegula, subtegular ridge, apex of scutellum, postscutellum, apical margins of first and second tergites centrally, apical and lateral margins of third and following tergites, sternites, and genitalia. Fore- and middle legs pale red, their coxae and trochanters yellow. Hind legs black, distitrochanter, extreme apex of femur, and upper half of coxa yellow. Upper part and apical half of antenna black.

Neoallotype

Male; resembling the neotype except in the following details: length 6 mm., antenna 26-segmented and not attenuate, propodeum densely verrucate, petiole 1.6 times as long as its apical width.

FIG. 4. *Smicroplectrus walleyi* n. sp., mesonotum, dorsal view.
FIG. 5. *S. incompletus* Walley, mesonotum, dorsal view.
FIG. 6. *S. californicus* (Cress.), head, dorsolateral view.
FIG. 7. *S. jucundus* (Hlgr.), head, dorsolateral view.
FIG. 8. *S. californicus* (Cress.), propodeum, lateral view.
FIG. 9. *S. jucundus* (Hlgr.), propodeum, lateral view.
FIG. 10. *S. annulipes* (Cress.), habitus.
FIG. 11. *S. californicus* (Cress.), hind basitarsus.
FIG. 12. *S. robustus* Walley, hind basitarsus.
FIG. 13. *S. apicatus* Walley, egg, lateral view.
FIG. 14. *S. apicatus* Walley, apex of egg, ventral view.
FIG. 15. *S. robustus* Walley, egg, dorsal view.
FIG. 16. *S. robustus* Walley, apex of egg, lateral view.
FIG. 17. *S. jucundus* (Hlgr.), egg and ovipositor.
FIG. 18. *S. takomae* n. sp., egg and ovipositor.

Color like that of the neotype except in the following details: cheek yellow only immediately below eye, propleuron black, only small spot in center of prepectus yellow, extreme apex of hind coxa below yellow, antenna black above but yellow below and brownish apically.

Variation

Females.—Length 5 to 9.5 mm.; temples convergent behind eyes at 30° to 45°; antenna 22- to 29-segmented, usually not attenuate; costula of propodeum usually absent but sometimes weak and incomplete; hind basitarsus six to eight times as long as wide; length of petiole 1.4 to 1.6 times apical width; abdomen usually coriaceous in boreal specimens. Antenna yellow to dark brown below, red to dusky apically; inner orbit occasionally extending above antennal socket, rarely (Alaska) with a detached yellow spot at top of eye; upper margin of pronotum often yellow at posterior corner only; scutellum often black in northern specimens; hind coxa from yellow above, below, and apically in southern specimens to yellow apically only or all black in most boreal specimens; hind femur sometimes dark red centrally, or, rarely, red with black apices but in California typically so.

Males.—Length 4.5 to 8 mm.; temples convergent at 25° to 45° behind eyes; antenna 23- to 28-segmented; costulae in more strongly carinated propodea sometimes weakly and incompletely present; propodeum shining and weakly verrucate to dull and strongly rugulose; length of hind basitarsus six to eight times width; length of petiole 1.4 to 1.8 times apical width. Antenna yellow to dark brown below and reddish to black apically; face in boreal specimens often with a narrow median line and clypeal suture black, in extreme cases median 0.8 of face black with two central yellow spots; pronotum often entirely black; prepectus normally black, rarely (Arizona) laterally yellow; scutellum usually black; hind coxa usually black; hind femur centrally reddish in Californian specimens.

Specimens Seen (over 50 ♂ ♂ & ♀ ♀)

Neotype.—Female, Moosonee, Ontario, July 18, 1934, G. S. Walley (CNC No. 6240).

Neoallotype.—Male, Bell's Corners, Ontario incubator-reared under Forest Insect Survey No. 048-910, host: larva of tenthredinid (CNC).

Other specimens.—ALASKA: Nome, Rapids at Mile 236 on the Richardson Highway. N.W.T.: Reindeer Depot on Mackenzie Delta, Coppermine, Norman Wells. B.C.: Robson, Pavilion Lake. CALIF.: Hope Valley in Alpine Co., near Sonora Pass at 8500 ft., Lake Tahoe, Portola, Buck's Lake in Plumas Co. ARIZ.: near Alpine. WYO.: Centennial at 10,000 ft. COLO.: Spring Creek Pass in Hinsdale Co. ALTA.: Larch Valley near Moraine Lake at 7500 ft. MAN.: Churchill. ONT.: Moosonee, Bell's Corners. QUE.: Nominingue.

This species is common in the Hudsonian Zone and occurs more sparingly in the Canadian and Transitional Zones.

The host is probably a poplar or willow feeding sawfly. The adults fly quite early in the season. Even in the Hudsonian Zone they are on the wing in June.

Smicroplectrus takomae n. sp.

This species is believed to be distinct from its sibling, *S. jucundus albilineatus* (Walsh), but is reliably separable from that species only in the female sex and often only by characters of the egg and ovipositor. The ovipositor of *takomae* is very slightly decurved at the tip, whereas that of *jucundus* is distinctly curved upward at the tip. The egg stalk of *takomae* is attached to the center of the ventral margin of the egg while that of *jucundus* is attached at the posterior apex. Both sexes may usually be distinguished from *jucundus* by the key characters.

With a little practice this species, as well as *jucundus*, may be distinguished from other species of the genus by the peculiar shape of the head (Fig. 7).

Holotype

Female; length 6.5 mm.; clypeal suture well-defined; temples convergent behind eyes at 30°; cheek and lower part of temple flattened and strongly receding; upper part of temple bulging strongly; vertex elevated; hypostomal carina about one-fifth as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at an acute angle; antenna broadening gradually toward apex, 24-segmented.

Prepectal carina vertical, without a branch curving under pronotum; sternaulix wide and very shallow; mesonotal flange well-developed, axillary tongue not well-developed; subtegular ridge projecting upward but scarcely meeting tegula when in closed position, not doubled posteriorly; mesopleuron shining and closely punctate, speculum occupying upper posterior fifth; scutellum shining and moderately punctate; propodeum slightly longer than deep, shining and vermiculately rugulose; median longitudinal carinae strong, but not laminately elevated; costula weak and irregular; middle and hind tarsal claws strongly pectinate with three to four large teeth; hind tibia spurred; width of hind basitarsus nine times length in lateral view, cylindrical.

Length of petiole 1.5 times apical width; petiole, second, and bases of third and fourth tergites rugulose, remainder of abdomen shining and finely punctate; ovipositor straight, slightly decurved at extreme apex, tapered from the center to a sharp point (Fig. 18).

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit to slightly above antennal socket with trace of detached spot at top of eye, cheek to one-third eye-height, propleuron, upper corner and lower margin of pronotum laterally, prepectus, tegula, subtegular ridge, extreme apex of scutellum, postscutellum, center of apical margin of tergites one and two, apical and lateral margins of remaining tergites, venter, and genitalia. Fore- and middle legs red with yellow coxae and trochanters. Hind leg black, apex of coxa and distitrochanter yellow; inner surface of center of femur reddish brown. Antenna black, yellow below, and reddish apically.

Allotype

Male; resembling the holotype except in the following details; length 6 mm.; antenna 23-segmented, hind basitarus seven times as long as wide, propodeum more strongly carinate.

Color resembling that of the holotype except in the following details: inner orbit black, cheek except malar space black, propleuron black, prepectus black, yellow margins of apical tergites narrower.

Egg

Ovate-reniform; the stalk very short and attached to the middle of the ventral surface; anchor small. Surface of egg not sculptured.

Variation

Female paratypes.—Length 4.5 to 6.5 mm.; temples convergent behind eyes at 20° to 30°; antenna 21- to 24-segmented; costula occasionally weak or incomplete; hind basitarsus 6.5 to 8 times as long as wide; sometimes apex of tergite two shining and smooth; length of petiole 1.45 to 1.55 times apical width. Inner orbit may be black or extend to top of eye; detached yellow spot at top of eye sometimes present, but rarely large; prepectus sometimes black behind fore-coxae; scutellum often black; hind coxa varying from black at base only to yellow at extreme apex only, rarely reddish above; hind femur and tibia red in Norman Wells specimens; usually hind legs dark brown rather than jet black as rest of body.

Male paratypes.—Length 4.5 to 6 mm.; temples convergent at 20° to 30° behind eyes; antenna 21- to 23-segmented; costula strong to absent, but usually weak; hind basitarsus 5.5 to 7 times as long as wide; petiole 1.5 to 1.8 times as long as apical width. Face rarely black above; lower margin of pronotum yellow to brown; prepectus yellow to black; apical 0.2 to 0.7 hind coxa yellow; hind legs usually dark brown, not jet black as rest of body.

Specimens Seen (about 85 ♂ ♂ & ♀ ♀)

Holotype.—Female, Mount Rainier, Washington, at 4700 ft., July 11, 1940, H. & M. Townes (Townes).

Allotype.—Male, Mount Rainier, Washington, at 5000 ft., July 9, 1940. H. & M. Townes (Townes).

Paratypes.—WASH.: about 80 ♂ ♂ and ♀ ♀, Mount Rainier, 4700 ft. to 5000 ft., July 9–21, 1940, H. & M. Townes (Townes). N.W.T.: 2 ♀ ♀, Norman Wells, June 14 and July 8, 1949, W. R. M. Mason, (CNC). ALASKA: ♀, Mile 103, Steese Highway, at 2500 ft., June 22, 1951, W. R. M. Mason, (CNC); ♀, Mile 250, Richardson Highway, at 2500 ft., June 25, 1951, W. R. M. Mason, (CNC).

This species appears to be confined to the Hudsonian Zone of the Western Cordillera. Like most boreal *Smicroplectrus*, it emerges very early in summer but nothing further is known of its habits.

I have seen specimens with egg and ovipositor appearing identical to those of this species among specimens from Finland determined as *Smicroplectrus jucundus* (Hlgr.)

Smicroplectrus californicus (Cresson)

Cteniscus californicus Cresson, 1878, Proc. Acad. Nat. Sci. Phila. p. 374 (o.d., ♀, California, type in ANSP).

Anderis californicus (Cress.) Davis, 1897, Trans. Am. Entomol. Soc. 24 : 234 (key, des.).

Auderis californicus (Cress.) Davis, 1898, Trans. Am. Entomol. Soc. 24 : 348 (Syn.).

Smicroplectrus californicus (Cress.) Walley, 1937, Can. Entomologist, 69 : 131 (Syn.).

Smicroplectrus disseptus Walley, 1933, Can. Entomologist, 65 : 256 (o.d., ♀, Agassiz, British Columbia, type in CNC).—Walley, 1937, Can. Entomologist, 69 : 136 (key, Ont., Que.).

Examination of a good many specimens from most parts of North America has convinced me that *californicus* and *disseptus* represent merely the red and black colors respectively, of one varicolored species. Any morphological differentiation seems to be missing. When larger series of specimens are available it may be possible to differentiate the various color patterns on a geographical basis and thus preserve Walley's name at the subspecific level. At the present moment, material is too scanty for such division to be wise.

This species is best distinguished from its near relatives in the *jucundus* group by the key characters. It is the only member of the group in which the body may become extensively red. Specimens from the northern parts of its range are sometimes difficult to tell from *S. robustus* Walley. Close attention must be given to the form of the hind basitarsus in such cases. In this species it is cylindrical whereas in *robustus* it is fusiform, and always distinctly broader in the middle than at either end (Figs. 11, 12).

Plesiotype

Female; length 6.5 mm.; clypeal suture strong; temples convergent behind eyes at 40°; cheek weakly convex and receding; head not elevated in vertical region, upper end of temple receding; hypostomal carina about one-quarter as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at nearly a right angle; antenna broadening gradually to the apex, 27-segmented.

Prepectal carina vertical, without a branch curving under pronotum; sternaulix wide and shallow; mesonotal flange and axillary tongue well-developed; subtegular ridge projecting upward to meet tegula when in closed position; mesopleuron shining and sparsely punctate, speculum occupying upper posterior third; scutellum shining and sparsely punctate; propodeum verrucate, slightly shorter than deep, strongly declivate from center of areola; medium longitudinal carinae strongly elevated; costula strong; middle and hind tarsal claws strongly pectinate with three to four large teeth; hind tibia spurred; width of hind basitarsus 6.5 times length in lateral view, cylindrical.

Length of petiole 1.3 times apical width; petiole rugulose, shining and weakly sculptured anteriorly; bases of second and third tergites rugulose,

remainder of tergites shining and closely punctate; ovipositor more or less straight, tapered to a sharp point in its apical third.

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit to slightly above antennal socket, cheek, propleuron, upper corner and lower margin of pronotum laterally, prepectus, tegula, subtegular ridge, apex of scutellum, postscutellum, central apical margin of petiole, apical margins of second and following tergites, venter, and genitalia. Fore- and middle legs red with yellow coxae and trochanters. Hind leg red with yellow distitrochanter and black tibia and tarsus. Hind basitrochanter dark above; hind femur red with dark apices. The following parts of the thorax red: upper posterior half of propleuron, all mesonotum except anterior margin and a central black stripe, scutellum except yellow apex, mesopleuron and mesosternum except yellow areas detailed above and some black marginal suffusions. Antenna black, reddish below and apically.

Alloplesiotype

Male; resembling the plesiotype except in the following details: antenna 26-segmented, hind basitarsus 5.7 times as long as wide, costulae of propodeum strong, petiole, second, and base of third tergites strongly rugulose.

Color resembling that of the plesiotype except in the following details: inner orbit black, cheek black except lower margin, propleuron red, black on pronotum reduced to saddle only, mesonotum entirely red except posterior quarter and longitudinal stripe on median lobe, no black upon mesopleuron or mesosternum, hind basitrochanter and hind femur entirely red, antenna entirely black above.

Egg

Broadly ovate; stalk terminal.

Variation

Females.—Length 5 to 7 mm.; temples convergent at 35° to 50° behind eyes; antenna 25- to 27-segmented; hind basitarsus 6 to 6.5 times as long as wide; petiole 1.1 to 1.6 times as long as apical width; all second and bases of third, fourth, and fifth tergites sometimes rugulose. Inner orbit sometimes yellow to top of eye; upper margin of pronotum sometimes yellow. Ground color of thorax varying from entirely black to entirely red, black appearing first in upper corner of pronotum and sides of propodeum and scutellum. In intermediate specimens (central California and eastern Canada) the following parts of the thorax are red: side of pronotum, lateral lobe of mesonotum, scutellum, lower part of mesopleuron, metapleuron, side of propodeum. In the reddest specimens abdominal tergites bearing lateral red marks and hind basitrochanter and femur entirely red. In the darkest specimens (British Columbia) only the four anterior legs and hind coxa red.

Males.—Length 5 to 8.5 mm.; temples convergent behind eyes at 40° to 55°; antenna 26- to 30-segmented hind basitarsus 5.0 to 6.0 times as long as wide and sometimes slightly fusiform; length of petiole 1.3 to 1.55 times

apical width; second tergite sometimes apically punctate; fourth tergite sometimes basally punctate. Hind coxa often yellow apically; propleuron sometimes partly yellow. The red and black balance varying similarly to that of the female, but averaging darker. In darkest males the hind coxa black below or dusky red and hind femur dusky red with black apices. In reddest specimens the abdomen and much of the propodeum and metapleuron black. Antenna from yellow to brown below.

Specimens Seen (28 ♂ ♂ & ♀ ♀)

Plesiotype.—Female, Oakland, California, May 1, 1937, E. S. Ross (Townes).

Alloplesiotype.—Male, Strawberry, California, June 28, 1948, Townes family (Townes).

Other specimens.—B.C.: Fort Nelson, Chilliwack, Cultus Lake, Victoria, Genoa Bay. WASH.: Kittitas Co., Vancouver. OREG.: Hood River. CALIF.: Riverside, Meadow Valley in Plumas Co., Smoky Jack Camp in Yosemite Park, San Jacinto Mts., Berkeley, China Flat in Eldorado Co., Strawberry, Oakland. ARIZ.: Pocket Creek in Sierra Ancha. MINN.: Plummer. ONT.: Ottawa, Jockvale, Bancroft. QUE.: Nomininge, Knowlton. N.H.: Bretton Woods. N.C.: Raleigh.

This species occurs from the Canadian to the Upper Austral Zones.

Individuals have been captured at various dates between March and October, indicating the probability of multiple generations. One specimen has been reared from an unidentified tenthredinid larva. Two more are said to have been reared from an unidentified *Neodiprion*, but this record must be viewed with doubt until confirmed.

Smicroplectrus robustus Walley

Smicroplectrus robustus Walley, 1937, Can. Entomologist, 69: 135 (o.d., key ♂, ♀, Que., type in CNC, Alta.).

This species is easily distinguished from all other *Smicroplectrus* except its nearest relative *S. apicatus* (Prov.) by the incrassate hind tarsi (Fig. 12). Females are not always easily separated without examination of the egg, and some males are quite indistinguishable. Typically the hind coxae are red, whereas those of *apicatus* are black, but in undersized males of either species they may be black or dusky or a variegated color.

Holotype

Female; length 10.5 mm.; clypeal suture very strong; temples convergent behind eyes at about 25°; hypostomal carina about one-third as high as its length below junction with occipital carina; occipital carina strong, meeting hypostomal carina at a right angle; antenna attenuate from middle, 36-segmented.

Prepectal carina without a branch curving under pronotum, vertical; mesonotal flange and axillary tongue strongly developed; subtegular ridge projecting upward to meet tegula in closed position; mesopleuron polished and

sparsely but coarsely punctate, speculum occupying upper central quarter; scutellum shining and sparsely punctate, slightly concave centrally; propodeum shorter than high, strongly rugulose and very strongly carinate; profile of propodeum strongly declivate from center of areola; middle and hind tarsal claws pectinate with five to six large teeth; tibia spurred; length of hind basitarsus five times width in lateral view, fusiform.

Length of petiole 1.2 times apical width; petiole strongly rugose; second, and bases of third, fourth, and fifth tergites coriaceous-rugulose; remainder of tergites shining and closely punctate; ovipositor more or less straight, tapered to a sharp point from the center.

Color black, the following parts yellow: mouth parts, clypeus, face except upper central third, cheek and postocciput to one-quarter eye-height, antenna below, propleuron centrally, upper corner and lower margin of pronotum laterally, prepectus, tegula, subtegular ridge, apex of scutellum, postscutellum, apices of first and second tergites centrally, apical margins of third and following tergites, venter and genitalia. Fore- and middle legs red with yellow coxae and trochanters. Hind leg with red coxa, basitrochanter, and femur; base and apex of femur dark, distitrochanter yellow. Hind tibia and tarsus black.

Allotype

Male: differing from the holotype in the following details: length 10 mm., temples convergent behind eyes at 40°, antenna 31-segmented, petiole 1.1 times as long as apical width; hind basitarus 4.5 times as long as wide; third, fourth, and most of fifth and sixth tergites coriaceous-punctate.

Color resembling that of the holotype except in the following details: postocciput and cheek behind black; all propleuron except very small central area black; prepectus black; hind basitrochanter black; apical and basal black markings of hind femur very extensive, nearly meeting on the outer surface; apex of hind coxa above yellow; antenna apically red.

Egg

Ovate; stalk terminal with a small basal swelling (Figs. 15, 16).

Variation

Females.—Length 6 to 11 mm.; temples convergent behind eyes at 25° to 45°; antenna 28- to 35-segmented; hind basitarsus five to six times as long as wide; propodeal costula weak or absent to strong; petiole 1.1 to 1.5 times as long as its apical width; second tergite and bases of third, fourth, and sometimes fifth tergites coriaceous to rugulopunctate. Upper half of face and central stripe sometimes black; hind coxa sometimes black apically below; hind basitrochanter, and hind femur except apices, varying from red to black.

Males.—Length 5.5 to 11 mm.; temples convergent behind eyes at 30° to 50°; antenna 27- to 31-segmented; hind basitarsus 4.5 to 6 times as long as wide; propodeal costula absent to strong; length of petiole 1.1 to 1.6 times

apical width; in smallest specimens only tergite two and base of tergite three coriaceous-rugose; in largest specimens tergites two, three, four, and bases of remainder rugulose to coriaceous. Face varying from lower half yellow (allotype) to central part entirely black with two small yellow median spots; hind coxa sometimes black apically below; hind basitrochanter and center of femur black to red.

Specimens Seen (5 ♂ ♂, 13 ♀ ♀)

Holotype.—Redescribed from the original female, Kazabazua, Quebec, June 12, 1935, ovipositing on larvae of *Nematus* on poplar, G. S. Walley (CNC).

Allotype.—Redescribed from the original male, Noranda, Quebec, June (CNC).

Other specimens.—ALTA.: ♂, ♀, Edmonton, June 3 and 4, 1949, W. R. M. Mason (CNC); ♂, Edmonton, Aug. 28, 1949, E. H. Strickland (Alta.); ♀, Fawcett, June 10, 1934, E. H. Strickland (Townes); ♀, Consort, July 20, 1948, E. H. Strickland (Alta.); ♀, Gull Lake, June 18, 1929, E. H. Strickland (CNC). NEV.: ♀, Jarbridge Canyon, Elko Co., Aug. 15, 1929, R. E. Balch (USNM). SASK.: ♀, Battle River north of Cut Knife, Aug. 26, A. R. Brooks (CNC); 3 ♀ ♀, Cut Knife, Aug. 29, 1940, A. R. Brooks (CNC). MINN.: ♂, Cook Co., June 20, 1937, Don Murray (Minn.). MICH.: ♀, Midland Co., June 25, 1940, R. R. Dreisbach (Dreis.). ONT.: ♀, Kawene, reared from unidentified tenthredinid larvae under Forest Insect Survey No. S48-1349B (CNC). N.Y.: ♂, Cranberry L., 19 June, 1928, B. A. Hartley (USNM). N.H.: ♀, Randolph, July 3, 1946, J. Peck and M. Townes (Townes).

The species appears to be confined to the Canadian Zone east of the Rocky Mountains.

Since specimens have been taken mainly in June or late August a 2-generation life cycle seems probable. From the scanty rearing records it is believed that this species attacks sawfly larvae on poplar.

Smicroplectrus apicatus (Provancher)

Cteniscus apicatus Provancher, 1879, Naturaliste can. 11 : 263 (o.d., ♀, Que., type in MPQ).

Anderis albilineatus Davis, 1897, Trans. Am. Entomol. Soc. 24: 234 (syn., in part).

Smicroplectrus apicatus (Provancher), Walley, 1937, Can. Entomologist, 69 : 135 (key, syn., des., host, Ont.).

The most distinctive feature of *S. apicatus* (Prov.) is the large, palmately lobed, transverse structure at the base of the egg stalk. It may be distinguished from all other species of *Smicroplectrus* except *S. robustus* Walley by the swollen hind tarsi. The hind basitarsus is somewhat fusiform and less than 5.5 times as long as its greatest width in lateral view (Fig. 12). From *robustus* this species is distinguished by its black or black and yellow (rarely reddish at the base) hind coxae and the unique egg.

This species falls in the *jucundus* group, and is most closely related to *S. robustus* Walley.

Plesiotype

Female; length 9 mm., clypeal suture strong; temples convergent behind eyes at about 45°; cheek rounded but not swollen; hypostomal carina about one-quarter as high as its length below junction with occipital carina; occipital carina obsolescent at lower end, meeting hypostomal carina at almost a right angle; antenna very slightly attenuate from the middle, 32-segmented.

Prepectal carina with a faint indication of a branch curving under the pronotum, the main branch vertical; sternaulix wide and shallow; mesonotal flange and axillary tongue strongly developed; subtegular ridge projecting upward to meet tegula in closed position; mesopleuron polished and punctate, speculum occupying upper posterior third; scutellum shiny and densely punctate, centrally concave; propodeum shorter than deep, strongly declivate from apical carina; median longitudinal and apical carinae very strong, costula and lateral longitudinal carina weak or absent; middle and hind tarsal claws pectinate with three to five large teeth; hind tibia spurred; hind basitarsus 4.6 times as long as wide in lateral view, fusiform.

Length of petiole 1.4 times apical width; petiole rugose and shiny; base of second tergite rugose, remainder of second, third, and base of fourth and fifth tergites rugulose-coriaceous, remainder of tergites shining and punctate; ovipositor more or less straight, tapered from the center to a sharp point.

Color black, the following parts yellow: mouth parts, clypeus, face, cheek and postocciput, scape and flagellum below, propleuron, lower margin and upper corner of pronotum, prepectus, tegula, subtegular ridge, apex of scutellum, postscutellum, central apical margin of first and second tergites, apical and lateral margins of third and following tergites, venter, and genitalia. Fore- and middle legs red, coxae and trochanters yellow. Hind leg black, coxa apically above and distitrochanter yellow.

Alloplesiotype

Male; resembling the plesiotype except in the following details: antenna not attenuate, 31-segmented, cheeks convergent behind the eyes at 50° and strongly rounded, propodeum more strongly verrucate and more strongly carinate.

Color resembling that of the plesiotype except in the following details: postocciput and cheeks behind black, propleuron black, hind femur yellow at extreme apex, antenna red apically.

Egg

Ovate-reniform; stalk terminal with a large, palmately lobed, transverse basal structure (Figs. 13, 14).

Variation

Females.—Length 6.5 to 9 mm., antenna 29- to 33-segmented; hind basitarsus 4.5 to 5.5 times as long as wide in lateral view and fusiform; costulae

of propodeum weak or strong, complete or incomplete; lateral longitudinal carina weak; all tergites apically and all of tergites three and four sometimes coriaceous. Propleuron sometimes black laterally to a lesser or greater extent; hind coxa often laterally and basally suffused with red, its upper third sometimes yellow; hind femur black to red centrally, usually reddish on inner side.

Males.—Length 6 to 9.5 mm.; antenna 24- to 31-segmented; temples convergent behind eyes at 30° to 55°; hind basitarsus 4.5 to 5.5 times as long as wide; propodeal costula varying from absent to strong, often incomplete. Prepectus sometimes bearing lateral yellow spots; hind coxa often basally suffused with red, in the extreme more than basal half red; apical yellow marking of hind coxa sometimes absent or sometimes occupying apical third; hind femur black to centrally red.

Specimens Seen (6 ♂ ♂, 12 ♀ ♀)

Plesiotype.—Female, Shuswap Falls, British Columbia, May 21, 1947, ovipositing on larvae of *Nematus nigriventris* Curran, B. A. Sugden (CNC).

Alloplesiotype.—Male, Taft, British Columbia, May 12, 1944, reared from *Nematus nigriventris* Curran, C. R. Hopping and C. V. G. Morgan (CNC).

Other specimens.—B.C.: ♂, Shuswap Falls, reared from unidentified tenthredinid larva under Forest Insect Survey No. BC49-405a (CNC); ♂, Robson, July 4, 1949, H. R. Foxlee (CNC); ♂, Robson, June 9, 1948, H. R. Foxlee (CNC); ♀, Robson, May 18, 1949, H. R. Foxlee (CNC); ♀, Fort Nelson, June 6, 1948, W. R. M. Mason (CNC). COLO.: ♂, Phantom Valley, Rocky Mountain National Park at 9400 ft., June 16, 1948, Townes family (Townes). ALTA.: ♂, Banff, June 15, 1948, E. H. Strickland, (Alta.). ONT.: 6 ♀ ♀, Jockvale near Ottawa, May 28, 1934, G. S. Walley (CNC and Townes). QUE.: ♀, Rigaud, May 24, 1941, J. Ouelet (USNM). MAINE: ♀, Mt. Desert I., June 3, 1931, (USNM). N.Y.: ♀, Six-mile Creek, Ithaca, May 18, 1949, attacking sawfly larvae on *Populus grandidentata*, W. R. M. Mason (CNC).

The species appears to be transcontinental in the Transition and Canadian Zones, but has not been taken on the Pacific Slope.

Specimens have been reared from *Nematus currani* Ross, a poplar-feeding sawfly. Most specimens have been captured in late spring and early summer.

Smicroplectrus incompletus Walley

Smicroplectrus incompletus Walley, 1937, Can. Entomologist, 69 : 134 (o.d., ♀, Mount Albert, Gaspé Co., Que., type in CNC, N.S.).

This species is very similar to *S. walleyi* n. sp. and *S. eburneus* n. sp. It is most easily distinguished from these two species by the black pleura and prepectus, but is most distinct in the long narrow mesonotal flange (Fig. 5).

Holotype

Female; length 10 mm.; temples convergent behind eyes at 40°; cheek strongly swollen but receding; hypostomal carina low, only about one-quarter as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at an acute angle, obsolete at the junction; antenna scarcely attenuate, 29-segmented.

Prepectal carina vertical, not curving under pronotum; sternaulix shallow, scarcely distinguishable; mesonotal flange and axillary tongue not well-developed, the flange about as high at posterior end as at middle (Fig. 5); subtegular ridge projecting upward to meet tegula in closed position, not doubled posteriorly; mesopleuron polished and moderately densely punctate, speculum occupying upper posterior third; scutellum convex, polished and closely punctate; propodeum longer than deep, strongly declivate at apical carina, smooth and finely punctate anteriorly, shining and weakly verrucate behind apical carina; apical carina strongly laminate; longitudinal carina and costula absent, their place completely smooth, shining, and impunctate; middle and hind tarsal claws pectinate with four to five large teeth; hind tibia spurred; width of hind basitarsus six times length in lateral view, cylindrical.

Length of petiole 1.15 times apical width; petiole strongly arched and strongly rugulose, second, third, fourth, and base of fifth tergites strongly rugulose, remainder of fifth and following tergites sparsely punctate; ovipositor slightly decurved, tapered from center to a sharp point.

Color black, the following parts yellow: mouth parts, clypeus, face, cheek and postocciput, scape below, upper and lower margins of pronotum laterally, propleuron, prepectus laterally, tegula, subtegular ridge, apex of scutellum, postscutellum, central apical margins of first and second tergites, apical margins of third and following tergites, sternites, and genitalia. Fore- and middle legs red with yellow coxae and trochanters. Hind leg black, apex of coxae above, distitrochanter and extreme apex of femur yellow. Antenna black, flagellum yellowish red below.

Allotype

Male; resembling the holotype except in the following details: length 7 mm., hind basitarsus 5.5 times as long as wide in lateral view, petiole 1.35 times as long as wide apically; third, fourth, and fifth tergites basally rugulose, apically shining, and sparsely punctate.

Color resembling that of the holotype except in the following details: face centrally black, cheek and postocciput black, propleuron black, prepectus black, genitalia brown.

Egg

Ovate, stalk apical and long; anchor small; surface of egg not sculptured.

Variation

Females.—Length 7.5 to 10 mm.; temples convergent at 10° to 40°; antenna 26- to 31-segmented; median longitudinal carinae of propodeum usually present, though often weak or absent; hind basitarsus 5.5 to 8 times

as long as wide; petiole 1.15 to 1.5 times as long as its apical width; third and fourth tergites may be apically punctatorugose. Antenna yellow to dark brown below; cheek sometimes yellow to one-third eye-height; prepectus sometimes entirely yellow; apical half or more of hind coxa yellow; hind femur and tibia occasionally reddish below.

Males.—Length 5.5 to 8 mm., temples convergent at 15° to 40°; antenna 22- to 29-segmented; median longitudinal carinae of propodeum sometimes weakly indicated; petiole 1.2 to 1.5 times as long as apically wide, its carinae often obsolete except basally. Face sometimes black centrally above and sometimes in addition, bearing a central black streak; hind coxa varying from entirely black except extreme apex above to more than apical half yellow.

Specimens Seen (8 ♂ ♂, 9 ♀ ♀)

Holotype.—Redescribed from the original female, Mount Albert, Gaspé Co., Quebec, 3500 to 3700 ft., July 21, 1933, W. J. Brown (CNC).

Allotype.—Redescribed from the original male, Kentville, Nova Scotia, June 3, 1923, R. P. Gorham (CNC).

Other specimens.—QUE.: ♀, Cascapedia River, Gaspé Co., July 13, 1933, M. L. Prebble, paratype (CNC); ♀, Windigo, incubator-reared from larva of *Pikonema* sp. under Reconnaissance des Insectes Forestiers No. 45-27277-A (CNC). ONT.: ♀, Seguin Falls, incubator-reared from larva of a tenthredinid under Forest Insect Survey No. S49-662A (CNC). VT.: ♀, Manchester, June 6, 1910 (MCZ). N.Y.: ♂, Van Natta's Dam, Ithaca, May 6, 1936, P. P. Babiy, (Townes). PA.: 4 ♂ ♂, Spring Brook, May 12, and 14, 1945, H. K. Townes (Townes); 2 ♀ ♀, Spring Brook, May 17, 1945, H. K. Townes (Townes). ALTA.: ♀, Lethbridge, June 12, 1938, (Alta.). ARIZ.: 2 ♂ ♂, Workman Creek, Sierra Ancha, Gila Co., April 28, 1947, H. & M. Townes (Townes); ♀, Oak Creek Canyon, Coconino Co., May 18, 1947, H. & M. Townes (Townes).

This species is widespread in the Canadian and Transitional Zones.

The only rearing record indicates that the species attacks *Pikonema*. The flight season is in spring and early summer.

Smicroplectrus eburneus n. sp.

This species may be distinguished from its near relative *S. walleyi* and *S. incompletus* by the characters discussed under those species. In addition it is distinguished from both by the yellow color of the hind coxae and inner orbits.

Holotype

Female; length 7 mm.; clypeal suture strong; temples convergent behind eyes at about 45°; cheek swollen; hypostomal carina about one-fifth as high as its length below junction with occipital carina; occipital carina weak, meeting hypostomal carina at nearly a right angle; antenna not attenuate, 29-segmented.

Prepectal carina vertical, evanescent above, not curving under pronotum; sternaulix wide and shallow; mesonotal flange and axillary tongue well-developed, but intermediate in development between those of *S. walleyi* and *S. incompletus* (Figs. 4, 5); subtegular ridge projecting upward to meet tegula when in closed position; scutellum convex, shining and sparsely punctate; propodeum shorter than deep, otherwise resembling that of *S. walleyi*; hind tibia spurred; hind basitarsus 6.5 times as long as wide in lateral view, cylindrical.

Petiole 1.3 times as long as wide apically; petiole rugose; bases of second and third tergites rugulopunctate; remainder of second and third and following tergites punctate and shining; ovipositor straight, tapering from middle to a sharp point.

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit broadly to top of eye, cheek and postocciput to about half the eye-height, scape, pedicel and flagellum below, propleuron, pronotum entirely except a black saddle, prepectus, mesosternum, lower anterior half of mesonotum except sternaulix, tegula, subtegular ridge, scutellum except central area, postscutellum, laminate corner of apical propodeal carina, central apical margin of petiole, apical and lateral margins of second and following tergites, venter, and genitalia. Fore- and middle legs red with yellow coxae and trochanters; apices of femora, bases of tibiae and middle tarsus yellow. Hind coxa and trochanters yellow, the basitrochanters clouded; hind femur red, extreme apex yellow with subapical dusky annulus; hind tibia black with basal yellow annulus and posterior yellowish stripe; tarsus black.

Egg

Ovate-reniform; stalk apical with a large basal swelling; anchor small.

Variation

Female paratypes.—Length 5 to 7.5 mm.; antenna 26-to 30-segmented. Mesosternum and mesopleuron sometimes entirely black, the holotype having the largest extent of yellow among the types.

Specimens Seen (4 ♀ ♀)

Holotype.—Female, Simcoe, Ontario, June 18, 1939, T. N. Freeman (CNC No. 6204).

Paratypes.—TEX.: ♀, College Station, April 4, 1936 (Townes). NO LOCALITY: 2 ♀ ♀, "8H", H. G. Dyar Collection (USNM).

This species has been taken in the Upper and Lower Austral Zones.

Smicroplectrus walleyi n. sp.

Smicroplectrus sp. near *incompletus*, Walley, 1937, Can. Entomologist, 69 : 134 (key, Que.).

S. walleyi is easily distinguished from *S. incompletus* by its broader mesonotal flange (Fig. 4) and red pleura. It is most easily distinguished from its other close relative, *S. eburneus* by the red pleura and postfurcal nervulus. In *eburneus* the nervulus is interstitial and the pleura black and yellow.

Holotype

Female; length 7 mm.; clypeal suture strong; temples convergent behind eyes at about 50°; cheek swollen and receding; hypostomal carina about one-third as high as its length below junction with occipital carina; occipital carina weak, meeting hypostomal carina at nearly a right angle; antenna attenuate from the middle, 28-segmented.

Prepectal carina vertical, not curving under pronotum; sternaulix shallow and wide; mesonotal flange and axillary tongue strongly developed, flange decidedly broadened behind tegula (Fig. 4); subtegular ridge projecting upward to meet tegula when in closed position; mesopleuron highly polished, sparsely punctate below; scutellum polished and punctate, collapsed and wrinkled centrally; propodeum as long as deep, highly polished and sparsely punctate anteriorly, shining and weakly rugose behind apical carina; apical carina laminate, longitudinal lateral carina and costula completely absent, their place smooth and shining; median longitudinal carinae present; middle and hind tarsal claws pectinate with three to four large teeth; hind tibia spurred; hind basitarsus six times as long as wide in lateral view, cylindrical.

Petiole 1.2 times as long as wide apically; petiole weakly rugose; base of second tergite weakly rugose; remainder of second and following tergites punctate, more sparsely so apically; ovipositor slightly decurved, tapered from center to a point.

Color black, the following parts yellow: mouth parts, clypeus, face, cheek, propleuron below, upper corner and lower lateral margin of pronotum, tegula, subtegular ridge, prepectus laterally and centrally, apex of scutellum, postscutellum, central apical margin of first and second tergites, apical margins of remaining tergites, sternites, genitalia. The following parts red: mesopleuron except upper 0.2, mesosternum, most of prepectus, metapleuron, propodeum laterally. Fore- and middle legs red, with knees and trochanters and coxae below yellow. Hind leg black; coxa red; distitrochanter, extreme apex of femur and extreme base of tibia yellow. Antenna black, reddish below and apically.

Allotype

Male.—Resembling the holotype except in the following details: antenna 27-segmented, hind basitarsus six times as long as wide in lateral view, petiole 1.5 times as long as wide apically, middle and hind tarsal claws with four to five large teeth.

Color resembling that of the holotype except in the following details: propleuron black, upper quarter of mesopleuron black, propodeum entirely black, hind coxa dusky apically.

Egg

Ovate; stalk long and apical, with a basal swelling; anchor small.

Variation

Females.—Length 5 to 8 mm.; antenna 28- to 30-segmented; temples convergent behind eyes at 30° to 60°; hind basitarsus six to seven times as

long as wide; petiole 1.2 to 1.7 as long as its apical width. Smallest specimens with all tergites but first and base of second smooth; in largest ones all second tergite and bases of third and fourth rugulocoriaceous. Scape below usually reddish; propleuron sometimes entirely yellow or dark red laterally; mesopleuron sometimes red below subtegular ridge; scutellum black to red; hind femur black or dark red.

A female from Ithaca, N.Y., is anomalous in coloration. The mesopleuron is entirely black except the subtegular ridge and lower posterior corner; mesosternum black; pronotum behind red; hind femur red with black apices.

Males.—Length 7 to 8 mm.; antenna 27- to 30-segmented; hind basitarsus 5.5 to 6.5 as long as wide. Antenna sometimes reddish below; propleuron varying from black and yellow to entirely red.

A male from Hull, Que., is anomalous in coloration. It has antenna yellow below; pronotum red below and above; propleuron mostly black; mesopleuron, mesosternum, and metapleuron entirely black; hind coxa yellow apically; and hind tibia red with dark apices. Both this male, and the female from Ithaca are unusually dark, and are the only specimens taken in May, whereas the others are all July and August captures. They may represent a spring generation.

Specimens Seen (8 ♂ ♂, 9 ♀ ♀)

Holotype.—Female, Midland, Ontario, August 21, 1955, J. G. Chillcott (CNC No. 6203).

Allotype.—Male, same data as holotype (CNC).

Paratypes.—QUE.: ♂, Hull, May 30, 1903 (CNC); ♀, Lac Brule, Aug. 7, 1945, O. Peck (CNC). N.Y.: 2 ♂ ♂, ♀, Farmingdale, July 3 & 10, 1935, H. & M. Townes (Townes); ♀, Ithaca, May 7, 1933, J. G. Franclemont (Townes); ♀, Shokan, July 9, 1936, H. K. Townes (Townes). PA.: ♂, Mount Holly Springs, July 21, 1918, R. N. Fouts (USNM); ♀, Marsh Run, York County, July 18, 1909, P. R. Myers (USNM). OHIO: ♂, Olmstead Falls, July 14, 1933 (Ohio); ♀, Ross Co., June 25, C. H. Kennedy (Ohio). NEBR.: ♂, Omaha, July 8, 1913, L. T. Williams (Univ. of Nebraska). MD.: ♀, Takoma Park, July 23, 1944, H. & M. Townes (Townes). VA.: ♀, Falls Church, July 14, 1920, William Middleton (USNM). KY.: ♂, Lexington, no other data (USNM).

This species occurs in the Alleghenian and Carolinian Zones.

Most captures have been in July and August. The two May records are without explanation unless two generations per year are assumed.

Smicroplectrus velox Walley

Smicroplectrus velox Walley, 1937, Can. Entomologist, 69 : 134 (o.d., ♀, Bell's Corners, Ont., key, des., ♂, ♀, type in CNC, Ont., Que., B.C.).—Brown, 1941, Can. Dept. Agr. Tech. Bull. 31 : 6 (host, Canada).

This species is easily distinguished from its near relatives *S. etrocaulus* and *S. annulipes* by the key characters. The easiest distinction is in the color of the hind tibiae which are nearly or entirely black.

Holotype

Female; length 7.5 mm.; clypeal suture strong; temples convergent behind eyes at 30°; cheek moderately swollen; hypostomal carina about one-half as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at a right angle; antenna attenuate from middle, 30-segmented.

Prepectal carina with a vertical branch as well as one curving under pronotum; sternaulix wide and deep; mesonotal flange and axillary tongue strongly developed; subtegular ridge not projecting upward, but doubled posteriorly with several ventrally subtending ridges; mesopleuron polished, sparsely punctate, speculum occupying upper posterior third; scutellum polished and punctate, very slightly excavated posteriorly; propodeum shorter than deep, strongly declivate from apical carina, polished, rugose and strongly carinate; middle and hind tarsal claws weakly pectinate with two to three very small teeth; hind tibia spurless; hind basitarsus eight times as long as wide in lateral view, cylindrical.

Petiole 1.1 times as long as wide apically; petiole rugose; second tergite longitudinally rugose basally and longitudinally rugulopunctate apically; base of third tergite weakly rugulopunctate, remainder of third and following tergites polished and punctate; ovipositor more or less straight, tapering strongly in the apical third.

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit nearly to top of eye, lower margin of pronotum laterally, propleuron, tegula, subtegular ridge and anterior margin of mesopleuron, prepectus, scutellum apically, postscutellum, central apical margin of petiole, apical margins of second and following tergites, sternites, and genitalia. Fore- and middle legs red, their coxae yellowish below; middle tarsomeres darkened apically. Hind legs with red coxa, dusky basitrochanter, yellow distitrochanter; hind tibia black with indistinct brown median annulus; hind tarsus black with bases of basal tarsomeres yellow. Antenna red, black above and basally.

Allotype

Male.—Resembling the holotype except in the following details; antenna 33-segmented, temples bulging and converging at only 15°, scutellum more strongly punctate, petiole 1.2 times as long as wide apically, abdomen closely punctate.

Color resembling that of the holotype except in the following details: central part of face black except two median yellow marks, cheek black, propleuron black, mesopleuron and prepectus black, hind leg black with distitrochanter and small basal annulus on the tibia yellow; large median annulus on the tibia and bases of basal tarsomeres yellowish brown. Antenna red below and black above.

Egg

Ovate, large, surface pattern at most indistinct; stalk long; anchor small.

Variation

Females.—Length 5 to 11 mm.; antenna 28- to 34-segmented; hind basitarsus 6 to 10 times as long as wide in lateral view; petiole 1.1 to 1.4 times as long as wide apically; smaller specimens generally less strongly sculptured and punctate than larger ones. Antennal scape occasionally red; two vertical black bars resembling those of the male occasionally present on the face; metapleuron and lower corner of mesopleuron usually red; large areas of lower half of mesopleuron occasionally red.

Males.—Length 6 to 10 mm.; antenna 29- to 33-segmented; hind basitarsus 8 to 10 times as long as wide in lateral view; petiole 1.1 to 1.4 times as long as wide apically; smaller specimens about as strongly sculptured and punctate as larger ones. Face sometimes entirely yellow or the central part entirely black; antennal scape occasionally red below; lower posterior corners of mesopleuron, metapleuron, and propodeum and apex of petiole occasionally reddish; hind coxa varying from entirely black to entirely red, usually red with a dark apical cloud; broad median annulus on hind tibia varying from black to dirty yellow.

Specimens Seen (about 130 ♂ ♂ and ♀ ♀)

Holotype.—Redescribed from the original female, Bell's Corners, Ontario, June 24, 1935, G. S. Walley (CNC).

Allotype.—Redescribed from the original male, same data as holotype but June 25, 1935 (CNC).

Other specimens.—B.C.: Vanderhoof, Lumby, MacLeod Meadows in Kootenay Park, Robson. N.MEX.: Jemez Springs. ALTA.: Edmonton, Lacombe. SASK.: Dahlton, Sutherland. ONT.: Kingston, Winchester, Stittsville, Bell's Corners, Mer Bleue near Ottawa, Oba, Owl Lake, Chapleau, Algonquin Park, Miller Lake. QUE.: Wright, Wakefield. P.E.I.: Queen's Co., Alberton. MAINE: Abbot.

This species has a transcontinental distribution in the Canadian and Transitional Zones, but has not been taken on the Pacific Slope.

Most of the specimens have been reared from *Pikonema alaskensis* (Rohwer). Two specimens are said to have been reared from *P. dimmockii* (Rohwer) and *Pristiphora erichsonii* (Hartig). Adults emerge in June, but females have been taken through June into July. Two females from Robson, B.C., were taken in September and may represent a second generation.

Smicroplectus annulipes (Cresson)

Cteniscus annulipes Cresson, 1868, Trans. Am. Entomol. Soc. 2 : 112 (o.d., ♀, Mass., type in ANSP).—Harrington, 1895, Can. Entomologist, 27 : 156 (Ont.).—Procter, 1938, Biol. Survey Mt. Desert Region, 6 : 413 (Maine).

Excavarus annulipes Davis, 1897, Trans. Am. Entomol. Soc. 24 : 233 (key, des., Ill., Mass.).—Mason, 1905, Entomol. News, 16 : 169 (Ill.).—Brimley, 1938, Insects of North Carolina, p. 413 (N.C.).

Smicroplectrus annulipes Walley, 1937, Can. Entomologist, 69 : 132 (key, syn., Ont., Que., in part).—Mason, 1951, *In* Hymenoptera of America North of Mexico, Synoptic Catalogue. *By* Muesebeck, Krombein, and Townes. U.S. Dept. Agr., Agr. Monograph, No. 1, p. 230 (in part).

Some of the records in the literature under this species actually refer to *S. etrocaulus* n. sp. Where the specimens in question have been examined and found to be incorrectly determined, the records have been corrected under *S. etrocaulus*. I have not verified the Mt. Desert record.

This species is easily distinguished from its close relatives, *S. etrocaulus* and *S. velox* by the key characters. Together with these two, it forms a species group here called the *annulipes* group.

Plesiotype

Female; length 11 mm.; clypeal suture strong; temples convergent behind eyes at 30°; hypostomal carina about half as high as its length below junction with occipital carina; occipital carina meeting hypostomal carina at an acute angle; antenna attenuate from middle, 29-segmented.

Prepectal carina curving under pronotum, without a vertical branch; sternaulix strong and crenulate; mesonotal flange and axillary tongue strongly developed; subtegular ridge not projecting upward, but doubled posteriorly with several ventrally subtending ridges; mesopleuron polished, sparsely punctate anteriorly and below; scutellum shining and wrinkled, somewhat concave centrally; propodeum shorter than deep, very strongly declivate from center of areola, strongly rugose and very strongly carinate; middle and hind tarsal claws pectinate with four to five large teeth; tibia spurless; hind basitarsus 6.5 times as long as wide in lateral view, cylindrical.

Petiole 1.1 times as long as wide apically; petiole strongly rugose; second tergite rugose laterally and basally, remainder of second and following tergites shining and punctate, more sparsely so apically; ovipositor more or less straight, tapered in its apical third (Fig. 10).

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit nearly to top of eye, cheek, lower margin of pronotum posteriorly, upper corner of pronotum, tegula, subtegular ridge, prepectus, apex of scutellum, postscutellum, apical margins of second and following tergites, sternites, genitalia. The following parts red: propleuron, lower 0.7 of mesopleuron, mesosternum, metapleuron, lower corner of propodeum, sides of scutellum. Fore- and middle legs red, their coxae and trochanters yellowish below; middle tarsus yellow with tarsomeres four and five dark. Hind leg with red coxa, brown basitrochanters, yellow distitrochanter; dark brown femur with pale reddish middle band and extreme apex yellow; black tibia with basal yellow annulus and broad median yellow annulus; black tarsus with bases of tarsomeres two, three, and four yellow. Flagellum reddish, dark brown above.

Alloplesiotype

Male; differing from the plesiotype in the following details: hypostomal carina only one-third as high as its length below junction with occipital carina,

antenna 28-segmented, sternaulix wide and not crenulate, hind basitarsus six times as long as wide, petiole 1.2 times as long as wide apically.

Color resembling that of the plesiotype except in the following details: cheek black, black mark about tentorial pit, propleuron black, prepectus laterally yellow, remainder of prepectus red, lower half of mesopleuron red, sides of scutellum black.

Egg

Large, ovate; stalk terminal and bearing a pair of broad basal lobes. Surface of egg covered with a hexagonal granular pattern.

Variation

Females.—Length 7 to 11 mm.; antenna 25- to 29-segmented; hind basitarsus six to seven times as long as wide; petiole 1.1 to 1.3 as long as its apical width. The more southerly specimens are smaller with less sculpture, finer puncturation, and larger red areas on the thorax and legs at the expense of the black. In the darkest specimens (Canada) the upper half of the mesopleuron and all scutellum and propodeum may be black and the prepectus centrally yellow. In the reddest southern specimens (South Carolina) red covers all the pronotum except a saddle, all the mesopleuron, the scutellum, and most of the prepectus. The hind basitrochanter and center of femur vary from blackish to red in the same fashion.

Males.—Length 6 to 11 mm.; antenna 23- to 28-segmented; smaller specimens much less strongly sculptured and more shining, especially on the abdomen. Propleuron frequently red; hind femur red to black; antenna usually yellow below.

Specimens Seen (about 30 ♂ ♂ & ♀ ♀)

Plesiotype.—Female, South Amherst, Massachusetts, June 24, 1898, George Dimmock (USNM).

Alloplesiotype.—Male, Wakefield, Massachusetts, March 16, 1932, reared from *Croesus latitarsus* Norton, Gypsy Moth Lab. No. 10024 T7 (USNM).

Other specimens.—N.B.: Fredericton. QUE.: Aylmer. ONT.: Georgetown, Constance Bay. MASS.: South Natick, Milton, South Amherst, Wakefield. CONN.: East River. R.I.: Westerly. N.Y.: Ithaca, Flatbush. PA.: Mount Holly Springs. MD.: Takoma Park, Forest Glen, Cabin John. VA.: Falls Church, Glencarlyn. S.C.: Greenville, Walhalla. ILL.: Hicks Branch at Eichorn. MINN.: Southeastern tip of Houston Co.

This species occurs in the Alleghenian and Carolinian Zones.

Both males and females have been taken throughout the summer from May to October. It seems evident that more than one generation is passed. Two rearings from sawfly larvae on birch and one from *Croesus latitarsus* Norton, presumably also on birch, are recorded.

Smicroplectrus etrocaulus n. sp.

Excavarus annulipes (Cress.) Walley, 1931, Ann. Rept. Entomol. Soc. Ontario, 61 : 93 (Montreal, Que., misdet.).

Smicroplectrus annulipes (Cress.) Walley, 1937, Can. Entomologist, 69 : 131 (Alta., Que., misdet. in part).—Mason, 1951, *In* Hymenoptera of America North of Mexico, Synoptic Catalogue. *By* Muesebeck, Krombein, and Townes. U.S. Dept. Agr., Agr. Monograph, No. 1, p. 230 (Alta., Colo., misdet. in part).

This species is similar to *S. annulipes* and all specimens have been discovered mixed with series of that species.

S. etrocaulus is readily distinguished from its close relatives, *S. annulipes* and *S. velox* by the key characters. It is most easily separated from *annulipes* by the color of the hind legs. In *etrocaulus* the hind coxa, both hind trochanters, and basal half or more of the hind femur are uniformly red; whereas these parts are of strongly contrasting colors in *annulipes*. In addition the scutellum of *etrocaulus* is strongly rugosopunctate, while that of *annulipes* is smooth and slightly wrinkled.

The species may be divided into two subspecies; one eastern, the other western.

Smicroplectrus etrocaulus etrocaulus n. ssp.

This subspecies, the western race, may be distinguished from the eastern race by the two vertical black lines on the face running from the antennal sockets to the tentorial pits, and by the entirely black second tergite.

Holotype

Female; length 11 mm.; clypeal suture very strong; temples convergent behind eyes at 20°; cheek strongly swollen; hypostomal carina about one-third as high as its length below junction with occipital carina; occipital carina meeting hypostoma carina at an acute angle; antenna attenuate from the middle, 28-segmented.

Prepectal carina with a vertical branch as well as one curving under the pronotum; sternaulix wide and crenulate; mesonotal flange and axillary tongue strongly developed; subtegular ridge not projecting upward but doubled posteriorly with several ventrally subtending ridges; mesopleuron polished, sparsely punctate anteriorly and below; scutellum rugosopunctate and apically excavated; propodeum shorter than deep, very strongly declivate from center of areola, strongly rugose and very strongly carinate; middle and hind tarsal claws pectinate with four to five large teeth; hind tibia spurless; hind basitarsus 5.5 times as long as wide in lateral view, cylindrical.

Petiole 1.1 times as long as wide apically; petiole strongly rugose; second tergite strongly longitudinally rugose; base of third tergites rugulose; remainder of third and following tergites polished and punctate, sparsely so toward apical margins; ovipositor small, strongly evenly decurved, and evenly tapered to apex.

Color black, the following parts yellow: mouth parts, clypeus, face except two black lines from antennal sockets to clypeal suture, inner orbit to slightly above antennal socket, lower margin of pronotum posteriorly, lower 0.7 of

propleuron, tegula, subtegular ridge, prepectus laterally, apex of scutellum, postscutellum, apical margins of third and following tergites, sternites, genitalia. The following parts red: lower third of mesopleuron, mesosternum, prepectus centrally, metapleuron, lower corner of propodeum. Fore- and middle legs red, their coxae and trochanters yellowish below; middle tarsus yellow, apices its joints darkened, fifth tarsomere black. Hind coxa and trochanters and basal 0.7 of hind femur red; apex of femur black; hind tibia black with a small basal yellow annulus and incomplete median yellow annulus; hind tarsal joints black, the basitarsus with basal half yellow. Antenna black, flagellum brown below.

Allotype

Male; resembling the holotype except in the following details: antenna 29-segmented, sternaulix not crenulate, petiole as long as wide apically.

Color like that of the holotype except in the following details: lower median part of propleuron yellow, genitalia dark, lower 0.5 of mesopleuron red, apical 0.5 of third and all fourth and fifth joints of middle tarus black, basal 0.8 of hind femur red.

Egg

Ovate, flattened ventrally; stalk in median ventral position, very short; anchor small; surface of egg not sculptured.

Variation

Female paratypes.—Antenna 28 to 31 joints; hind basitarsus to 6.5 times as long as wide; propleuron sometimes marked as that of allotype; extent of red on mesopleuron varying from lower half to lower posterior corner only; propodeum sometimes entirely black; median yellow annulus of hind tibia usually crossed by a ventral brown line.

Specimens Seen (♂, 4 ♀ ♀)

Holotype.—Female, Gull Lake, Alberta, June 14, 1929, E. H. Strickland (CNC No. 6202).

Allotype.—Male, Marguerite, British Columbia, reared from unidentified tenthredinid larva under Forest Insect Survey No. BC48-961a (CNC).

Paratypes.—ALTA.: ♀, Bilby, July 21, 1924, Owen Bryant (CNC). OREG.: ♀, Wallowa Lake, Aneroid Lake Trail at 6400 ft., July 22, 1929, H. A. Scullen (USNM). COLO.: ♀, Granite Peaks Camp at 9000 ft., Bayfield, July 17–31, 1928, J. Bequaert (MCZ).

This subspecies occurs in the Canadian Zone in the West.

Smicroplectrus etrocaulus eurus n. ssp.

This subspecies is readily distinguished from the typical one by the absence of the two vertical black bars on the face and by the presence of an apical yellow margin on the second tergite.

Holotype

Female; resembling the holotype of the typical subspecies except in the following details: hypostomal carina about one-half as high as its length below junction with occipital carina, antenna 28-segmented, hind basitarsus six times as long as wide in lateral view, petiole 1.2 times as long as wide apically, sternaulix strong and crenulate.

Color resembling that of the holotype of the typical subspecies except in the following details: face entirely yellow, prepectus entirely yellow, apical margins of second tergite yellow, red present only on lower posterior corner of mesopleuron and posterior median part of mesosternum, no red on prepectus or propodeum, yellow annulus of hind tibia incomplete, hind third tarsomere colored.

Variation

Female paratypes.—Length 10 to 12 mm.; petiole 1.0 to 1.2 as long as wide apically; inner orbit sometimes yellow nearly to top of eye; all propleuron usually yellow; red areas on thorax sometimes more extensive than in type, at maximum occupying all mesosternum and lower half of mesopleuron; sternaulix sometimes yellow; fore- and middle coxae and trochanters sometimes bright yellow below.

Specimens Seen (6 ♀ ♀)

Holotype.—Female, Tabustinac, New Brunswick, July 19, 1939, J. McDunnough (CNC No. 6201).

Paratypes.—QUE.: ♀, Montreal, collector Winn, no further data (CNC); ♀, Ile d'Orléans, July 23, 1943, Paul Morriset (USNM). MASS.: ♀, Holliston, Aug. 18, Nathan Banks (MCZ). MICH.: ♀, Isle Royale, Aug. 3–7, 1936, C. Sabrosky (USNM). MINN.: ♀, Itasca Park, July 12, 1938, J. Mondek (Minn.).

This subspecies has been taken only in the humid Canadian and Alleghenian Zones.

STUDIES ON VITAMIN REQUIREMENTS OF LARVAE OF THE ONION MAGGOT, HYLEMYA ANTIQUA (MG.), UNDER ASEPTIC CONDITIONS[1]

By W. G. Friend[2] and R. L. Patton[3]

Abstract

Larvae of the onion maggot, *Hylemya antiqua* (Mg.), were reared individually under aseptic conditions on chemically defined diets. Of 11 growth factors tested, biotin, pantothenic acid, choline, folic acid, pyridoxine, riboflavin, niacin, and thiamine were essential for normal growth and development of the larvae. Omitting one of vitamin B_{12}, thioctic acid, or coenzyme A slowed larval development slightly; fewer larvae pupated, and the ratio of male to female flies was high. However, these growth factors were not essential under the experimental conditions. This is believed to be the first chemically defined diet that will support the growth and development of a phytophagous insect under aseptic conditions. The check diet, which contained all of the vitamins tested, consisted of 19 *l*-amino acids, 9 B vitamins, coenzyme A, thioctic acid, inosine, thymine, ribonucleic acid, glucose, cholesterol, a salt mixture, and agar.

Introduction

The vitamin requirements of insects have been studied by many workers and the subject has been reviewed by Uvarov (28), Wigglesworth (29), Craig and Hoskins (4), Trager (26), Fraenkel (5), Brues (3), and Roeder (21). The reviewers agree that most species of insects require thiamine, riboflavin, nicotinic acid, pyridoxine, and pantothenic acid.

Aseptic conditions and chemically defined media have been used in many more studies on unicellular microorganisms than on multicellular animals. Some workers (1, 10, 11, 13, 15, 22) have applied these techniques to studies on the nutrition of certain Diptera. This is a report on a method by which a phytophagous dipteron can be studied free from microorganisms and on a chemically defined diet.

To date, the best chemically defined diets developed for dipterous insects seem to be those of House (11) for *Pseudosarcophaga affinis* (Fall.) and Hinton *et al.* (10) for *Drosophila melanogaster* (Mg.). Those of House allowed development of 83.9% of the aseptic larvae from hatching to the third instar within 20 days, and 59.9% of the larvae formed pupae. Hinton's diet allowed development of nearly 100% of the eggs to the adult stage, pupation occurring in six to seven days (only one to two days slower than normal).

Methods

The check diet was based on those of House (11) and Hinton *et al.* (10). The composition of this diet, which contained all of the vitamins tested, is given in Tables I–III. The diet was chemically defined as far as possible.

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TABLE I

COMPOSITION OF THE BASIC DIET

Constituents	Amount per ml. of diet	
	Mgm.	μgm.
Agar	20.0	
Ribonucleic acid	1.0	
Inosine	0.03	
Thymine	0.004	
Cholesterol	0.1	
Dextrose	15.0	
Mineral mixture U.S.P. XIII, No. 2*	2.0	
Amino acid mixture (See Table II)	24.21	
Vitamin mixture (See Table III)		77.96
Distilled water, 1000 ml.		

**Calcium biphosphate, 13.58%; calcium lactate, 32.70%; ferric citrate, 2.97%; magnesium sulphate, 13.70%; potassium phosphate (dibasic), 23.98%; sodium biphosphate, 8.72%; sodium chloride, 4.35%.*

TABLE II

COMPOSITION OF THE AMINO ACID MIXTURE

Amino acid	Concentration in diet, mgm./ml.
l-Alanine*	1.09
l-Arginine† (free base)	0.80
l-Aspartic acid†	1.22
l-Cysteine* (free base)	0.48
l-Glutamic acid†	4.42
Glycine†	1.75
l-Histidine† (free base)	0.48
l-Hydroxyproline*	0.38
l-Isoleucine†	1.26
l-Leucine*	2.35
l-Lysine HCl†	1.34
l-Methionine†	0.34
l-Phenylalanine*	1.01
l-Proline*	1.68
l-Serine†	0.88
l-Threonine†	0.38
l-Tryptophan†	1.75
l-Tyrosine†	1.24
l-Valine*	1.36
Total	24.21

**Mann Research Laboratories Inc., New York, U.S.A.*
†Nutritional Biochemicals Corporation, Cleveland, Ohio, U.S.A.

TABLE III

COMPOSITION OF THE VITAMIN MIXTURE

Vitamin	Concentration in diet, μgm./ml.
Biotin (aqueous solution)	0.020
B_{12}	0.040
Calcium pantothenate	6.0
Choline chloride	20.0
Coenzyme A*	1.5†
Folic acid	6.0
Nicotinic acid	10.0
Pyridoxine HCl	30.0
Riboflavin	2.4
Thiamine HCl	1.5
Thioctic acid‡	0.5
Total	77.96

**Not yet classed as a vitamin but suspected of having vitamin activity in H. antiqua.*
†Equals 217 × 10^{-6} Lipman units.
‡dl-6-Thioctic acid; donated by Lederle Laboratories, Division of the American Cyanamid Company, New York, U.S.A. All other vitamins used were supplied by Nutritional Biochemicals Corporation, Cleveland, Ohio, U.S.A.

This diet being used as a base, a series of 11 diets was formulated. Each of the diets in the series lacked one of the vitamins or growth factors listed in Table III; in all other respects it was identical with the check diet. Another complete diet similar to the check but with the level of all of the vitamins raised 12.5% was also used.

Preparation of Diets

The diets were prepared in the following way: the amino acids listed in Table II, excepting aspartic acid, glutamic acid, tryptophan, and tyrosine, were weighed in amounts required to make 1 liter of medium and ground together in a mortar. Enough tyrosine for 1 liter of medium was dissolved in 100 ml. of hot water to which 3 ml. of concentrated hydrochloric acid had been added. The tryptophan was dissolved in 100 ml. of warm water. The glutamic and aspartic acids were each dissolved in 66 ml. of warm water. The solutions of these four amino acids were then combined and the mixture of the remaining amino acids was added and dissolved.

The one gram of ribonucleic acid in the diet was dissolved in 20 ml. of 2 *N* sodium hydroxide plus 70 ml. of water. The inosine and thymine solution was made by adding 75 ml. of hot water plus 0.25 ml. of concentrated hydrochloric acid to 30 mgm. of inosine and 4 mgm. of thymine. This solution was warmed over a steam bath for one hour.

The two grams of U.S.P. XIII number 2 salt mixture, used in 1 liter of diet, was dissolved in 277 ml. of hot water.

The 15 grams of dextrose, used in 1 liter of diet, was dissolved in 25 ml. of warm water.

A stock suspension of cholesterol was made by dissolving 500 mgm. of cholesterol in 20 ml. of hot 95% ethyl alcohol. This was then pipetted into 100 ml. of cold water to which 0.3 ml. of polyoxyethylene sorbitan monooleate (Tween 80, Brickman and Company, Montreal, Canada) had been added. This gave a milky suspension, which was reduced to 60 ml. by evaporation to remove as much of the alcohol as possible.

The vitamins and cofactors were dissolved individually. The folic acid was dissolved in 20% ethyl alcohol, the thioctic acid in 95% ethyl alcohol, and the riboflavin in 0.02 *N* warm acetic acid. The remaining vitamins were dissolved in distilled water.

A series of 13 graduated flasks was used in compounding the diets. The proper vitamins were pipetted into each flask. The salt solution was decanted into a large beaker and the amino acid mixture in solution was added to it. The ribonucleic acid and inosine and thymine solutions were added and the pH of the mixture was adjusted to 6.1 and 2 *N* sodium hydroxide. Twenty grams of agar was added and the mixture was autoclaved to melt the agar. After two minutes in the autoclave at 15 lb. pressure, the mixture was removed, 100 mgm. of cholesterol in suspension and the dextrose solution being added. The hot mixture was dispensed into the graduated flasks containing the vitamin mixtures. These flasks were held at 80° C. to keep the agar melted. The diets were dispensed into 1-dram screw-capped vials that were used as diet tubes. The cardboard cap liners were removed from the bakelite caps so that the caps could be thoroughly cleaned. Approximately 1 ml. of diet was placed in each tube. The diet tubes were marked, loosely capped, and autoclaved for 15 min. at 15 lb. pressure.

After sterilization, the diet tubes were removed from the autoclave and stacked so that the agar formed slants in the tubes. Slants were made so that any moisture given off as the agar solidified would run to the bottom of the slant and not drown the larvae.

Sixty tubes of each of the diets were compounded in this fashion.

Preparation of Aseptic Eggs

Eggs were obtained from a large culture of the onion maggot that had been maintained throughout the winter in a greenhouse, the larvae having been reared on onions, and the adults having been fed honey and brewers' yeast. The eggs used were all less than 24 hr. old, the authors having found that older eggs cannot be disinfected satisfactorily. The eggs were immersed in 6.5% formalin solution for 30 min. and washed in sterile water. Of the 1016 eggs treated in this manner, 12.8% showed bacterial contamination, and 16.7% although aseptic, did not hatch. After being washed in sterile water, the eggs were transferred to the surface of the experimental diet in the diet tubes by means of a platinum loop. The loop and the mouth of the diet tube were flamed at each transfer to maintain aseptic conditions in the diet tube, one egg being placed in each tube.

Assay Procedure

After the treated eggs had been placed on the surface of the diet in the diet tubes, the tubes were placed in an incubator held at 26° C. throughout the assay period. Each day, the tubes were inspected with a dissecting microscope. The larvae hatching from the eggs could be seen tunnelling in the transparent diets. The morphological changes in the mouth hooks from instar to instar provided an accurate means for measuring larval development. Brooks' (2) descriptions of the mouth hooks were used in these determinations. In all cases larval development on the experimental diets was compared with that on the check diet, which contained all of the growth factors tested. The method described by Litchfield (16) was used for statistical comparisons.

Records were kept of the development of each larva. The diet tubes were inspected in different order each day to minimize the bias. Eggs that had not hatched five days after being placed on the diet were considered dead and diet tubes containing these eggs were reinfested.

Some of the larvae wandered just before they molted and crawled into the threads in the screw caps of the diet tubes. They were then almost impossible to find and they frequently died in this position. Therefore, larvae that could not be found for five consecutive days were considered lost and the tubes containing them were reinfested.

Larvae that died within three days of hatching were omitted from the experiment because of the possibility that they had been poisoned by the formalin treatment used to disinfect the eggs.

As soon as sign of contamination by microorganisms was noticed in any of the diet tubes, the contaminated tubes were discarded. Since the chemically defined diets used to rear the maggot would also grow microorganisms as successfully as the standard plating media used in normal bacteriological practices, plating samples from the apparently sterile diet tubes onto other media as a check for asepsis was judged to be unnecessary. The few tubes that were plated onto proteose–peptone agar, nutritive caseinate agar, and potato dextrose agar confirmed the belief that if microorganisms were present they would grow on the chemically defined test diets, forming colonies that could easily be detected.

Previous studies had shown that approximately 20% of the eggs treated with formalin for surface sterilization would not hatch. It was also expected that some of the larvae would wander into the screw caps of their diet tubes and die. To minimize these effects, tubes that contained no living larvae and that were still sterile 15 days after the first group of eggs had been placed on the diets were reinfested with fresh eggs that had been treated exactly as before. In no case did larvae hatching from the second group of eggs feed on the eggs or the egg shells left in the tubes from the first group.

The normal adults obtained from the different diets were inspected to determine their sex and then caged together in a glass jar 18 in. high and 10 in. in diameter. They were fed honey and brewers' yeast, a growing onion plant being included in the cage. The plant was inspected every three days for eggs. In all, 52 adults were caged, 19 males and 33 females.

TABLE IV

PERCENTAGES OF INSECTS REACHING VARIOUS STAGES AND STATISTICAL SIGNIFICANCES OF THEIR RATES OF GROWTH ON DIETS LACKING VARIOUS VITAMINS

Diet	Maximum number on diet†	Insects reaching 3rd instar: % of maximum number on diet	Insects reaching 3rd instar: Slope function (S)‡ and confidence limits at 5% level	Insects reaching 3rd instar: ET50§ and confidence limits at 5% level, days	Insects reaching pupal stage: % of maximum number on diet	Insects reaching pupal stage: Slope function (S)‡ and confidence limits at 5% level	Insects reaching pupal stage: ET50§ and confidence limits at 5% level, days	Insects reaching adult stage: % of maximum number on diet	Insects reaching adult stage: Sex ratio ♂ : ♀
Check	40	92.4	1.21 ± 0.07	6.6 ± 0.4	72.4	1.21 ± 0.06	14.8 ± 0.9	70.0	0.86 : 1
High level vitamin	33	97.0	1.07*± 0.03	6.3*± 0.1	94.0	1.14*± 0.04	13.3*± 0.7	87.9	0.93 : 1
Biotin-free	50	22.0	—	0*	0	—	0*	0	—
B_{12}-free	43	76.7	1.21 ± 0.03	7.0 ± 0.4	53.2	1.23 ± 0.08	15.7 ± 1.2	46.6	2.33 : 1
Choline-free	34	79.6	1.18 ± 0.05	7.0 ± 0.4	0	—	0*	0	—
Coenzyme A-free	43	86.1	1.15 ± 0.03	7.2 ± 0.3	69.8	1.16 ± 0.05	15.2 ± 0.8	65.2	1.80 : 1
Folic acid-free	36	80.6	1.15 ± 0.04	7.2 ± 0.3	2.8	—	0*	0	—
Nicotinic acid-free	42	2.2	—	0*	0	—	0*	0	—
Pantothenic acid-free	34	14.7	—	0*	0	—	0*	0	—
Pyridoxine-free	30	0	—	0*	0	—	0*	0	—
Riboflavin-free	44	0	—	0*	0	—	0*	0	—
Thiamine-free	39	2.5	—	0*	0	—	0*	0	—
Thioctic acid-free	38	79.0	1.25 ± 0.07	7.6*± 0.6	58.0	1.22 ± 0.08	14.8 ± 1.0	50.1	1.11 : 1

†*Only sterile insects in normal diet tubes considered.*
‡*Equivalent to the standard deviation.*
§*The time required for 50% to reach the indicated stage of development.*

TABLE V

INDEXES† OF LARVAL GROWTH

Diet	Maximum number on diet	Stage of development: Third instar larva N, %	Third instar larva T, days	Third instar larva N/T index	Pupa N, %	Pupa T, days	Pupa N/T index	Adult N, %	Adult T, days	Adult N/T index
Check	40	92.4	7.1	13.0	72.4	14.5	5.0	70.0	25.5	2.7
High level vitamin	33	97.0	6.8	14.3	94.0	13.9	6.8	87.9	25.7	3.4
Biotin-free	50	22.0	9.9	2.2	0	—	—	—	—	—
B_{12}-free	43	76.7	7.1	10.8	53.2	14.3	3.7	46.6	25.9	1.8
Choline-free	34	79.6	7.3	10.9	0	—	—	—	—	—
Coenzyme A-free	43	86.1	7.4	11.6	69.8	15.1	4.6	65.2	26.7	2.4
Folic acid-free	36	80.6	7.4	10.9	2.8	23.0‡	0.1	0	—	—
Nicotinic acid-free	42	2.2	7.0‡	0.3	0	—	—	—	—	—
Pantothenic acid-free	34	14.7	9.4	1.6	0	—	—	—	—	—
Pyridoxine-free	30	0	—	—	—	—	—	—	—	—
Riboflavin-free	44	0	—	—	—	—	—	—	—	—
Thiamine-free	39	2.5	8.0‡	0.3	0	—	—	—	—	—
Thioctic acid-free	38	79.0	7.6	10.6	58.0	16.1	3.6	50.1	26.8	1.9

†*N = percentage of maximum number on diet to reach stage of development under consideration, and T = average time in days to reach the stage of development under consideration.*

‡*Based on one insect.*

Results and Discussion

Tables IV and V summarize the results. Table V gives the development rates in terms of a growth index described by Trager (27). It took 6.6 days for 50% of the larvae on the check diet to reach the third instar, in comparison with 10.5 days for larvae reared on onions under the same incubator conditions.

Table V shows that 70% of the larvae on the check diet reached the adult stage. These adults appeared normal in every way. The larvae on this diet reached the pupal stage in 14.8 days, or in about two-thirds of the time taken under field conditions. Increasing the level of the 11 vitamins used in the check diet by 12.5% improved the diet markedly. Table IV shows that the high-level vitamin diet was superior to the check diet in every respect; the larvae developed at a faster rate and 87.9% of them reached the adult stage.

The biotin-free diet caused 78% of the larvae to die before reaching the third instar and none of the remaining larvae lived to form pupae. The growth index for third-instar larvae on this diet (Table V) was only 2.2 as compared with 13.0 for those on the check diet, and the development rate was significantly slower (Table IV). Since no pupae were formed without it, this vitamin is essential for *H. antiqua*. *H. antiqua*, therefore, like *Drosophila melanogaster*, differs from microorganisms that are able to utilize aspartic acid for their biotin requirements (14, 23).

Lack of vitamin B_{12} caused slightly higher mortality in all stages of development than occurred on the check diet. Only 46.6% of the B_{12}-deficient larvae became adults as compared with 70% on the check diet (Table IV). The growth indexes of larvae lacking B_{12} were consistently lower than those of larvae on the check diet (Table V). Table IV indicates that there was no significant decrease in the rate of development and that the course of development, as shown by the parallelism of the growth curves, was not altered significantly by lack of vitamin B_{12}. The ratio of males to females on the B_{12}-free diet was 2.3 to 1 as compared with 0.86 to 1 on the check diet. The Chi-square test showed this difference to be non-significant. Hinton *et al.* (10) found that B_{12} benefited pupation in *Drosophila melanogaster* and that omitting it caused consistent though small decreases in growth. House (12) obtained similar results with *Pseudosarcophaga affinis*.

On the diet lacking pantothenic acid, 95.5% of the larvae died before they reached the third instar; none pupated (Table IV). The deficiency was not apparent until the second instar was reached. Since Novelli (20) has shown that one of the active forms of pantothenic acid is coenzyme A, it is probable that the pantothenic acid requirements were partially fulfilled by the coenzyme A in the diet. All other species of Diptera that have been studied critically need pantothenic acid (8, 12, 15, 24, 25).

Lack of choline affected the larvae as they were about to pupate; 79.6% on the choline-free diet reached the third instar but none pupated. Development from hatching to third instar was slightly inferior to that of larvae on the check diet (Table IV). Choline is considered necessary for most species of insects studied (1, 6, 7, 12, 18).

Omitting folic acid caused an effect similar to that of choline deficiency in that the larvae had difficulty in pupating. Table IV shows that 80.6% of the larvae on the diet lacking folic acid reached the third instar but only 2.6%, one larva in 36, pupated. This insect died in the pupal stage. Many of the larvae, when the time came for them to pupate, became immobile and showed darkening of the exoskeleton characteristic of pupation, but they did not form true pupae. The larvae did not shorten and thicken and the third instar mouth hooks were not shed within the pupal skin. Others have reported that folic acid was needed for pupation in *Aedes aegypti* (L.) (8, 9), *Culex molestus* Forsk. (15), and *Drosophila melanogaster* (1). Moor (17) reported that this vitamin was needed for normal growth by *Attagenus* spp. Noland (19) stated that lack of folic acid sometimes caused an increase in the growth rate of *Blatella germanica* (L.).

Lack of pyridoxine caused 43.6% mortality in the first instar, and the remaining larvae all died before reaching the third instar. Table IV shows that the larvae on the pyridoxine-free diet developed at a much slower rate than larvae on the check diet. Pyridoxine is essential, therefore, for *H. antiqua* as it is for most insects upon which critical diet studies have been made (1, 6, 10, 15, 19, 24). Hinton *et al.* (10) found that high concentrations of pyridoxine retarded development of *Drosophila melanogaster*.

All larvae on the riboflavin-free diet died before reaching the third instar. The larvae began dying within two days after hatching; two-thirds of the total reached the second instar only to die in this stage (Table IV).

When niacin was omitted from the diet the effects were remarkable. The larvae reached the second instar without mortality and then 97.6% of them died. Only one larva reached the third instar before dying.

Table IV shows that larvae on the coenzyme A-free diet developed at about the same rate and appeared as healthy as larvae on the check diet. There were no significant differences between the two diets, either in reaction time or in development, as measured by the parallelism of the growth curves. Fewer females developed to the adult stage on the coenzyme A-free diet than on the check diet. The ratio of males to females was 1.8 to 1 for the former diet and 0.86 to 1 for the check. The Chi-square test showed that these results do not differ significantly. With 6.0 μgm. of calcium pantothenate per gram of coenzyme A-free diet, the insects probably synthesized their coenzyme A requirements.

Thioctic acid deficiency caused higher mortality at all stages of larval development than was shown by the check diet. Only 50.1% of the larvae on the diet lacking thioctic acid became adults whereas 70% of the larvae on the check diet reached this stage. The growth index at all stages of development was lower on the diet lacking thioctic acid than on the check diet (Table V). The development rate from hatching to third instar was slowed enough to cause a significant difference in reaction times between larvae on the thioctic acid-free diet and those on the check diet (Table IV). At pupation, the differences in development rates were not significant. Apparently

H. antiqua can meet its needs for thioctic acid by synthesis; however, development is speeded if this factor is supplied. Hinton *et al.* (10), working with *Drosophila melanogaster*, were unable to show that so-called protogen (crude thioctic acid) was a requirement or that it influenced the development of this insect. Kandar and LaFleur (13) found that the addition of "protogen" to their experimental diet had no effect upon the development of larvae of *Phaenicia sericata* (Mg.).

Omission of thiamine from the diet caused 97.5% of the larvae to die before reaching the third instar; 1 larva of 39 on the diet reached the third instar but died before pupating. Thiamine, therefore, is an essential vitamin for *H. antiqua*. It has also been found necessary for most other species of insects studied (26).

During the experiment, 50.2% of the 1016 specimens were discarded because of contamination, death, or loss.

The larvae on the diets that allowed complete development came to the surface of the diet to pupate and adults emerged from pupae left in the diet tubes. In some cases the emerging adults became stuck in the diet and their wings did not develop normally. The 52 adults that were caged together laid only four eggs. This scarcity of eggs may have resulted from unsatisfactory cage conditions; adults of the onion maggot do not oviposit under adverse conditions.

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NOTES

CAPILLARID WORMS FROM CANADIAN BIRDS

By Patricia M. Mawson

Among the nematodes in the collections at the Institute of Parasitology, the following species of capillarid worms were identified by the writer:

(1) *Capillaria falconis-nisi* (Diesing) from the intestine of an unknown species of owl collected on Montreal Island and from the great horned owl, *Bubo v. virginianus*.

(2) *Capillaria anatinis* (Schranck) from the intestine and caeca of the black duck, *Anas rubripes*, and the goldeneye duck, *Glaucionetta clangula americana*. The birds were collected on Montreal Island.

(3) *Capillaria ovopunctatum* (von Linstow) (= *C. quinscali* Read, 1949) from the intestine of the European starling (*Sturnus vulgaris vulgaris*), and the bronze grackle (*Quiscalus quiscula*) from Montreal Island.

Boyd (1) has recently identified this species from numerous starlings in various parts of the United States. She considers it possible that other capillarids recorded from American starlings (*Capillaria columbae* var. *sturni* Cannon, 1939 and *Capillaria caudinflata* Read, 1949) may prove to belong to *C. ovopunctatum*. It seems unlikely that this should be the case for the species reported by Read (5) because he records the presence of prebursal alae in the male, which are absent in *C. ovopunctatum*. From Cannon's (2) unillustrated description of the posterior end of the male of his species, it is not clear whether a prebursal swelling is present, and the author has been unable to locate Cannon's type material for re-examination. *Capillaria quiscali* Read, 1949 agrees with *C. ovopunctatum* in all but the hook on the spicule mentioned by Boyd. The mamillated structure of the egg shell figured by Read is not mentioned by Boyd, but presumably inspired von Linstow's trivial name.

Neither Boyd nor Read describe the shape of the head. In the Canadian specimens it is conical with an annular constriction at the base of the cone.

(4) *C. caudinflata* (Molin) from the intestine of the robin (*Turdus m. migratorius*), collected on Montreal Island. The dimensions and proportions of the specimens of both sexes, and the appearance of the male worms, agree with those of *C. caudinflata*. In no specimen was a bacillary band seen. The female worms differ in having a shorter vulvar flap than that figured by Morgan (4) and Madsen (3). The prevulvar notch, considered characteristic, is only slightly developed in the author's specimens but is as evident as in the figures of these authors. The shape of the posterior end of the female agrees with Morgan's description and figures.

The specimens differ from *Capillaria exilis* (Dujardin) redescribed by Boyd (1), in the presence of a vulvar flap as well as in the size of the eggs.

What may be this same species was also found in the duodenum of a pheasant from British Columbia and the intestine of a grouse from the Northwest Territories. As only female specimens are available, however, it is impossible to assign them to a species. In body size, size and shape of the eggs, appearance of the vulva and the posterior end of the body, they resemble each other and also *C. caudinflata* (though with a slightly shorter vulvar flap). The eggs are much smaller than those described by Boyd (1) for *C. exilis*.

(5) *Capillaria* spp. Female worms only were recovered from a number of birds.

(*a*) From the crow, *Corvus b. brachyrhynchos*, from Montreal Island. Although males were absent, these specimens are tentatively referred to *Capillaria collaris* v. Linstow, which they resemble in the characteristic annular constriction around the base of the head, the egg size, the absence of a vulvar flap, and the ratio of body parts.

(*b*) From the oesophagus of a blue-winged teal, *Querquedula discors*, collected locally. These worms agree in all respects with *Capillaria contorta*, which apparently occurs in a wide variety of birds.

(*c*) Worms collected locally from *Anas platyrhynchos domesticus*, *Anas rubripes*, and *Anas clangula hiemalis* could not be identified beyond the genus.

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TRICHOSTRONGYLID WORMS FROM CANADIAN BIRDS

By Patricia M. Mawson

Among the nematodes in the collection at the Institute of Parasitology, the following species of trichostrongylid worms were identified by the writer:

(1) *Amidostomum cygni* Wehr from the intestine of the whistling swan, *Cygnus columbianus*, from the proventriculus and gizzard of the king eider duck, *Somateria spectabilis*, from Hudson's Bay and the Ungava Peninsula, and from the proventriculus of the red-throated loon, *Gavia stellata*, from Ungava Peninsula.

Wehr (5) described the species from *Cygnus columbianus*, from Washington, D.C., U.S.A. The present specimens differ from those described by Wehr only in the size of the egg. The eggs of the female from the swan measure from 70 to 80 μ by 38 to 40 μ, and those from the duck 90 by 50 μ. Wehr's measurements are much smaller, namely, 58 to 62 μ by 35 μ.

(2) *Amidostomum anseris* (Zeder) from the intestine and proventriculus of the swan, *Cygnus* sp. The spicules in these specimens are longer (0.33 mm.) than those described by Travassos (3) (200 μ) but, according to his scale drawings ((3), Pl. 174, Fig. 4, Pl. 175, Fig. 2), the spicules are sometimes 300 μ. The form of the bursa is similar to that figured by Travassos.

(3) *Amidostomum spatulum* Baylis from the gizzard of the greater snow goose, *Chen hyperborea atlantica*. As only female worms are present, identification is tentative but the specimens are assigned to this species chiefly because of the form of the head on which there are four "epaulet-like" cuticular swellings, each associated with a submedian papilla (1). The species has been recorded by Wehr (4) from *Branta canadensis* from New York.

(4) *Trichostrongylus tenuis* (Mehlis), from the caeca of the blue goose, *Chen caerulescens*, from the Northwest Territories, and the snow goose, *Chen hyperborea atlantica*. Cram and Wehr (2) have fully redescribed this species from a number of host species from Europe and America, including the blue goose from the United States. The measurements of the present specimens fall well within the limits given by these authors. This is the first record of this species from Canada.

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